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SUGAR-CANE RESEARCH.

BRIEF mention has already been made in these columns of the Imperial Sugar-Cane Conference which was held last summer under the auspices of the Empire Marketing Board. More recently a copy of the *Report of the Proceedings of this Conference has reached us which throws considerably more light on the scope and results of its deliberations. The Conference's main object, it will be remembered, was to survey the whole field of sugar-cane research in the Empire with a view to its co-ordination and development. Opportunity was accordingly afforded to all Empire sugar-growing countries (including sugar beet countries) of sending representatives, of submitting statements showing the economic position of their sugar industry and of describing the present scope and organisation of their research activities. Thus, apart from containing the resolutions of the Conference, the Report of the Proceedings comprises an admirable review of the economic and scientific aspects of the sugar-cane industry in the British Empire. Not only have important memoranda issued by the territories represented been printed, together with a statement on *The World Economic Survey of Sugar* from a Report by the Ministry of Agriculture and Fisheries, the principal author of which is Mr. B. A. Foster, but also papers by Dr. Barber on *Sugar-Cane Economics*, by Dr. Hudson on *Sugar-Cane Research in the British Empire*, by Dr. Thompson on the *Biological Control of Sugar-Cane Pests*, by Mr. Ashby on *Quarantine and the Spread of Sugar-Cane Diseases*, by Mr. Freeman on *By-Products of the Sugar-Cane Industry* and a Report by Mr. Glendon Hill on *A Visit to the Proefstation Oost-Java*.

Important recommendations were made as a result of the valuable information collected. It was recognised that there was scope for measures of closer co-operation in the development of sugar-cane production in the Empire and that provisions should be made for the interchange of information through promoting inter-territorial visits by specialists. The need was stressed for further surveys of the economic position by the Imperial Economic Committee, for investigations into the relative efficiency of large and small units of cultivation, for enquiries into the conditions affecting the efficiency of labour in the sugar-cane industry in various territories and for a closer study of the utilisation of sugar by-products. In view of the fact that a principal item in the cost

* *E. M. B.* Imperial Sugar-Cane Research Conference, London, 1931. Report of Proceedings. *H.M.S.O.*, price, 2s. 6d., net.

of production of sugar is the expense of cultivation it was urged that adequate provision for work on the improvement of agricultural methods should be included in research programmes. The Conference advocated the setting up of four central cane breeding stations in India, Australia, Mauritius and the West Indies, whose programme would include morphological work of the kind involved in a study of root systems, in correlation with physiological studies, and the collection, of older canes and especially of those still growing in a wild or a semi-wild state. The Conference, after expressing its approval of the services rendered to the sugar-cane industry by the Imperial Institute of Entomology and the Imperial Mycological Institute, urged the extension of research on the biological control of insect pests and the provision of central quarantine stations, in appropriate areas, as safeguards against the possible introduction of fungous diseases.

The Conference considered a memorandum drawn up by a Special Committee appointed for the West Indian Area and endorsed its recommendations, commending them to the favourable consideration of the Governments concerned, which included Jamaica, Trinidad, British Guiana and Barbados. This memorandum contains proposals for the setting up of a central cane breeding station in Barbados, two-thirds of the annual cost of which, estimated at between £9,000 and £10,000, it is hoped will be borne by Barbados, and the remaining one-third by the Empire Marketing Board. It is indicated that the work carried out by such a station would be of particular value to other sugar-growing areas in the West Indies, especially if adequate provision were made by the local Departments for carrying out varietal trials of canes sent out. A grant from the Empire Marketing Board for £1,000 for a period of three years is recommended to continue the work which is in progress in British Guiana. For Trinidad, assistance from Imperial Funds is recommended for three years, to the extent of two-thirds of the total estimated cost, for carrying out Soil, Ecological and Entomological investigations in connection with the Estate Cultivation of Sugar-Cane and investigations in connection with Cane Farming in the Island.

The Imperial College of Tropical Agriculture is concerned in two ways. It has been requested, when the Central Cane Breeding Station has been in operation for some time, to initiate research work into fundamental problems connected with sugar-cane. Amongst these are included an investigation of sterility in varieties of cane, a cytological investigation into the chromosomes of the cane types and varieties employed in cane breeding work in the West Indies, and an investigation of the problem of hybrid vigour and heterosis. The College has also been chosen, mainly because of the specialist staff available, as a centre near which a quarantine station for the West Indian Area could be set up. Such a station, in view of the obvious dangers which it may involve, would throw great responsibilities upon the Quarantine Committee which it is proposed should control it, but if all due precautions were taken there is no reason why it should not render very effective services to local as well as other West Indian interests.

THE NEED FOR BIOLOGISTS.

According to a paragraph in *Nature* (Vol. CXXVIII, No. 3233) Dr. Martin Leake is stated to have voiced a plea for the establishment of biology on the basis of a real profession. Of late years there has arisen a widespread demand for trained biologists due to the post-war development of the Colonies, which lie mainly in the tropics. The demand exceeds the supply, and this is not adequately explained by lack of educational facilities. The basal trouble appears to be the lack of that security of tenure and emolument which is essential if workers of the right calibre are to be attracted to biological study. At present the biologist has such a restricted and specialised market for his services that security is attained only under the wing of other professions. His work is chiefly needed in connection with agriculture, which is beginning to substitute a firm scientific foundation for the empiricism which has hitherto been the guiding principle for the majority of those practising agriculture as a profession.

As Dr. Martin Leake remarks, the upsetting of the balance of nature in colonial development has raised a multiplicity of field problems needing investigation by trained research workers, and under present conditions it is only the Government which is in a position to provide the necessary funds, which will thus entail a single employer, the Colonial Office. A few other interests, especially tea and rubber, have begun to employ biologists, but so far the demand from such quarters is too small to affect the professional question. Dr. Leake indicates the need for a link between research and practice, the fact that the generalisations of research frequently need interpretation with local requirements, and that the research organisation does not replace, but complements, the technical staff within the commercial unit. Such a development, if it took place on a scale materially to affect the system of agricultural production in the tropical Empire, would do much to improve the status of biology as a profession, would increase the demand for trained biologists, would provide security and adequate remuneration, and would remove the dangers inherent in the concentration of demand for services in the hands of a single employer.

TRINIDAD FUNGI.

Copies (price 2*s*. each) of a list of Trinidad Fungi compiled by C. A. Thorold can now be obtained on application to the Editor of this Journal.

TOMATO DISEASES IN TRINIDAD.

BY

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Introduction.

THE cultivation of tomatoes in Trinidad forms part of an industry which chiefly concerns small gardeners who supply the local market with vegetable produce in the neighbourhood of densely populated districts. Fields are planted with the crop practically all the year round but the time of planting depends chiefly on the situation and proximity to a water supply. During the wet season, which lasts from June to January, most of the planting takes place on hill land and in the drier localities. These crops are picked from September onwards when the price is fairly high. Large tracts of flat land are also planted at the end of the wet season so that the fruit ripens in February, March and April, when, owing to better yields per acre, prices are at their lowest. During the dry season, planting is restricted to those lands with a good water supply, and thus considerable areas of rice land are planted with tomatoes in February, and to some extent, in March and April, after the rice has been harvested. These fields mature in June, July and August when the price is usually at its highest.

No tomatoes are at present exported from Trinidad and there are no indications that the supply will ever be sufficiently large or certain enough for the development of an export trade. In view, however, of recent attempts in the British West Indies to promote a large export trade in fruit and vegetables with Canada, the Mycology Department of the Imperial College of Tropical Agriculture has, during the past year, been conducting investigations into certain diseases of tomatoes. Some of these are still in progress but it is hoped that the results already obtained will benefit both local and other West Indian tomato producers. The work has involved not only the recording of various fungous diseases and insect pests to which the crop is liable but also the growing of a number of varieties of tomatoes in an attempt to determine those best suited to commercial requirements. For the latter purpose account has been taken of such factors as (*a*) resistance to disease; (*b*) shape and size of fruit; (*c*) yield; (*d*) keeping qualities, &c. During the enquiry visits were paid to numerous gardens and thanks to the willing co-operation of their owners it was possible to collect much useful material for laboratory examination. The present paper purports to deal with some of the main pests and diseases which occur in the Colony and to indicate in what directions the enquiry should be continued.

Wilt Diseases.

Wilt diseases in general probably constitute the worst type of disease with which planters have to contend. Not only are affected plants killed prematurely, but the causal organism usually persists in the soil for a number of years, and may do damage to subsequent crops. In Trinidad, tomato plants are commonly destroyed by three different wilt-producing organisms, namely:—*Bacterium solanacearum*, *Fusarium lycopersici*, and *Sclerotium rolfsii*. On different occasions each of these has been observed to be capable of causing almost a total loss of crop. As infection usually takes place from the soil, the need for proper rotation of crops is emphasised.

Bacterium solanacearum (E. F. SMITH) E. F. SMITH.

The occurrence of *Bacterium solanacearum* has been reported from very many countries, and the organism appears to flourish especially well in hot climates. Its hosts are very numerous, the bacterium having been recorded as the cause of diseases of plants in about 25 different families. Members of the *Solanaceae* appear to be particularly susceptible. In Trinidad the disease has been observed in the following districts:—St. Augustine, San Juan, Diego Martin, Caura and Aripo. Occasionally it is serious enough to destroy about 70 or 80 per cent. of the plants by the time the first fruits are formed.

Symptoms.

The symptoms caused by the bacterium vary according to the different hosts, but here they are described only as they occur on tomatoes.

Affected plants are usually first noticed when they have reached the wilting stage, but prior to this condition plants frequently assume a stunted appearance. When the plants wilt, they do so quickly and completely, without a preliminary distinct yellowing or browning of the lower leaves, and soon die. If stems are cut across with a sharp knife at intervals until the affected region is reached, the vascular stands and occasionally the pith will be found discoloured brown. After a short time, a dirty greyish or brownish ooze mainly composed of the causative bacterial cells is usually discharged from the cut ends of the vessels, and collects as small droplets, often visible to the naked eye. In some cases the extensive destruction of the pith by the bacterium results in the formation of large cavities.

Isolation.

The microscopical examination of hand sections of plants with these symptoms revealed the presence of bacteria in the vessels and sometimes in the pith. Numerous cultures of the bacterium were obtained by placing small fragments of infected material on a potato-sucrose medium, and from these, plates were poured to ensure that the organism obtained was pure. The same bacterium was isolated in practically every case.

Inoculation Experiments.

Inoculation experiments were carried out on tomato plants which were grown in the greenhouse in unsterilised soil. The plants were of two

varieties, namely, Stone in tins Nos. 1 to 4, and Bonny Best in tins Nos. 5 to 13. The seed had been sown in tins Nos. 1 to 9 on 12th May, 1931, and in tins Nos. 10 to 13 about a month earlier.

Experiment I.

As a preliminary trial, ten plants in tin No. 1, 21 plants in tin No. 2 and 13 of the 15 plants in tin No. 5 were inoculated on 18th May, 1931, with a bacterium obtained from isolation XXXV. The method of inoculation consisted of sterilising a mounted needle, dipping it into a culture of the organism growing on a sterilised potato block, and pricking the plant stems four or five times, about three inches from the tips.

Five days after the plants had been inoculated, symptoms of disease similar to those caused by *Bacterium solanacearum* were evident. The punctures had enlarged and were brownish-black in colour. The stems just above or below the punctures were rather distorted, or flattened, and were covered with numerous small incipient roots. Many of the leaf petioles near the inoculated area were reflexed, and several leaves were wilting. On the ninth day, the 44 inoculated plants all showed signs of wilting. On the 20th day six plants were dead, and four wilting in tin No. 1, 14 were dead and seven wilting in tin No. 2, and seven were dead, six wilting, and two healthy in tin No. 5. All the un-inoculated plants were still healthy.

Experiment II.

As symptoms of disease followed the inoculation of tins Nos. 1, 2 and 5, in Experiment I, a second experiment was initiated on 23rd June, 1931. Some plants were inoculated in the same way as before, others were pricked with the needle after it had been sterilised, and others were given no treatment. The heights of the plants in tins Nos. 1 to 9 were eight to twelve inches, and about two feet in tins Nos. 10 to 13. The numbers of plants and their treatments are given below :—

Tin.	*No. of Plants.*	*Treatment.*
III	14	None (Control).
IV	6	Pricked (Control).
VI	11	Pricked and inoculated.
VII	13	Pricked (Control).
VIII	19	Pricked and inoculated.
IX	4	Pricked (Control).
X	1	Pricked and inoculated.
XI	3	Pricked and inoculated.
XII	4	None (Control).
XIII	4	Pricked (Control).

The day after the treatments had been given, the inoculated wounds were brownish in colour, and formed a distinct contrast to the other wounds which were inconspicuous and not discoloured. On the third day the sites of inoculation were more conspicuous. The petioles of some of the inoculated plants were beginning to reflex, and leaves were already wilting. The stems of the smaller inoculated plants were slightly distorted or flattened in appearance in the vicinity of the wounds. On the fourth day this distortion was more pronounced, and was seen to be chiefly due to the production of numerous incipient roots, which were visible as small whitish swellings. By the fifth day, the incipient roots were definitely protruding. Of the 34 plants inoculated, 16 were now wilting. The individual leaflets of the wilting leaves hung quite limply, but there was usually a slight curling, either upwards or downwards, of the margins. On the seventh day the position of the discoloured vascular strands of many of the infected stems could be seen superficially as brown streaks. Photographs were taken of healthy and infected plants from tins Nos. 9 and 10 respectively (Fig. I) and from tins Nos. 7 and 8 (Fig. II). The vascular bundles of the infected plants were brown in colour for a distance of three or four inches above and below the inoculated wounds. Microscopical examination of sections of the stems in this region revealed the presence of numerous bacteria in the discoloured vessels. Cultures XXIX and XL of the bacterium were re-isolated from both plants by placing fragments of the infected stems on plated agar, and by pouring plates. Fifteen days after the inoculations had been carried out, 11 of the remaining 32 inoculated plants had died, and the remainder with the exception of the single plant in tin No. 10 were wilting. The damage due to a caterpillar necessitated the removal of one of the control plants in tin No. 4, but with this exception, all the control plants (pricked and unpricked) were still healthy.

The bacterium was re-isolated from two plants in tin No. 5 and three plants in tin No. 6 (Isolations XLI to XLV respectively). Microscopical examinations of all these plants and of three additional plants from tin No. 6 resulted in the observation of bacteria in the vessels and the brown discolouration as previously described.

Experiment III.

On the seventeenth day the organism re-isolated from the plant in tin No. 11 (Isolation XL) was re-inoculated into the 12 plants growing in tin No. 7. As a control, the five plants in tin No. 4 were again pricked with a sterile needle. In the course of four days, the plants in tin No. 7 had already become distorted in the neighbourhood of the pricks, and incipient root formation had begun. Later the other characteristic symptoms of the disease were developed, viz.: the reflexion of the leaf petioles, wilting, the brown discolouration in the vascular bundles, and in five cases, death. The control plants (those in tin No. 4 had been pricked twice) were all perfectly healthy at the termination of the experiment on 14th August, 1931.

It is interesting to note that six plants in tins Nos. 1, 2 and 8 all of which had been inoculated, showed no signs of wilting at the end of the experiment. The distorted areas on the stems bearing the incipient roots were still apparent, but the plants had renewed their growth, and appeared to have recovered from the disease.

TOMATO DISEASES IN TRINIDAD.

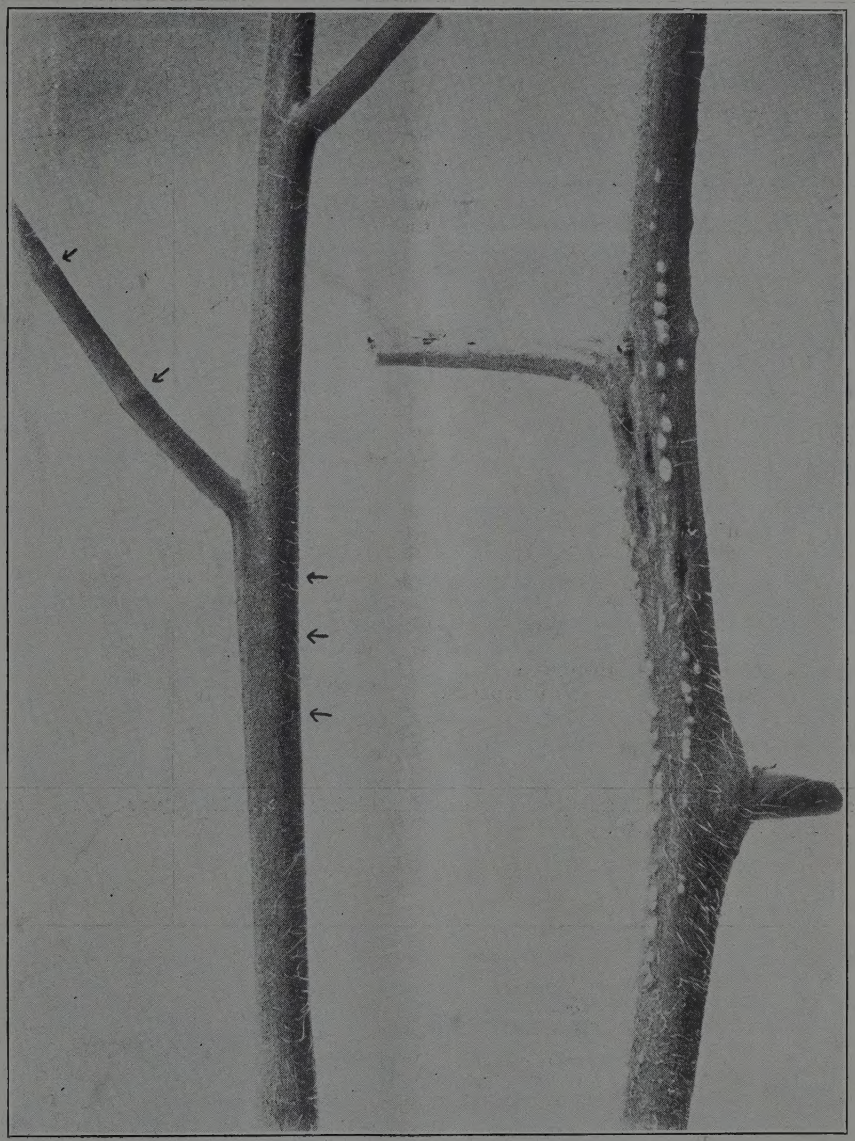

FIG. 1.—*Left :—Tomato stem pricked at arrows with sterile needle.*
Right :—Tomato stem pricked with needle dipped into a culture of "Bacterium solanacearum" Note incipient root production.

TOMATO DISEASES IN TRINIDAD.

FIG. 2—*Left :— Inoculated tomato plant (arrows indicate points of inoculation), note reflexed petioles.*
Right :— Control plant.

FIG. 3—*Left :— Inoculated plants showing obvious signs of wilting.*
Right :— Control plants.

Special mention may also be made of the plant in tin No. 10 which, being a single plant, was nearly three feet high when it was inoculated. The organism was inserted into the stem about 15 inches above the soil level (near the axil of the ninth leaf) and again near the top of the plant. Three days later, the petioles of the eighth, ninth, and tenth leaves all formed angles of about 75° with the stem above their points of attachment. On the sixth day the eighth and ninth petioles were perpendicular to the stem and the tenth leaf was reflexed. By the eighth day, the angles of all three leaves had increased to 105°-110°. Two leaves were also reflexed at the top of the plant near the second site of inoculation. One of these top leaves wilted on the tenth day, and the second 11 days later. The plant died about five weeks after being inoculated.

Identification of the Bacterium.

To determine the morphology and physiology of the organism, experiments were carried out in the laboratory which conformed as nearly as possible to the methods recommended by the Society of American Bacteriologists (8)*, (3). The observation and tests were made with pure cultures obtained from five different isolations. The cultures with the exception of a few on gelatine media, were kept at a room temperature of about 27° to 30°C. Duplicate un-inoculated tubes were treated in the same manner as the inoculated ones, as controls. The cultural and other characters of the bacterium as far as they have been determined are given below. The bacterial units consisted of small white rods, about .5μ × 1.5μ and occurred singly or in pairs. Motile cells were present in young broth cultures. The organism was Gram negative.

Gelatine stab.—A white circular glistening growth appeared in two days on the surface of the medium. Some of the tubes were kept in a cold chamber at 16°C. for five weeks and no liquifaction occurred. Others were kept at 27°C. to 30°C. for two weeks and when put into the cold chamber at 16°C. the gelatine had not lost its capacity to gel.

Agar colonies.—A white or greyish-white circular glistening growth appeared which was slightly brown in colour when held up to the light. The superficial appearance soon became brownish.

Agar slant.—A smooth whitish or greyish growth formed which was inclined to run, and later to turn brown. When grown on potato-sucrose agar-slants a brownish or blackish pigmentation was produced which diffused down into the medium. On malt-extract agar, no growth was produced.

Broth.—Cultures in broth produced turbidity and a whitish deposit.

Litmus Milk.—Lavender-coloured litmus-milk turned blue in about four days.

Potato blocks—A greyish-white growth was produced which later darkened to brown or black.

Indol formation was not indicated by the Gnezda oxalic acid test when the organism was grown in peptone water.

Nitrates were reduced to nitrites in a nitrate-peptone solution. Nitrites were detected by (1) the sulphanilic acid and *a*-naphthylamine test and (2) Metaphenylene diamine in the presence of sulphuric acid.

No gas and no acid were produced from sucrose or glucose media. Growth only took place in the open arms of the fermentation tubes.

Starch was not hydrolysed in a .2 per cent. soluble starch broth, and there was no acid production.

The temperature relations were not determined.

The above description agrees in all respects with that given by Bergey for *Phytomonas solanaceara* (E. F. Smith) Bergey *et al.*, and there is no doubt that the two descriptions are of the same bacterium. The more usual name for this organism, and the one which will be used here, is *Bacterium solanacearum* (E. F. Smith) E. F. Smith. In order to avoid confusion the following list of synonyms for *Bacterium solanacearum* (E. F. Smith) E. F. Smith is quoted from Elliott (11).

Bacillus solanacearum E. F. Smith, 1896.
Bacillus nicotianae Uyeda, 1904.
Bacillus sesami Malkoff, 1906.
Pseudomonas sesami Malkoff, 1906.
Bacillus musae Rorer, 1911.
Pseudomonas solanacearum E. F. Smith 1914.
Bacillus musarum Zeman, 1921.
Erwinia nicotianae (Uyeda) Bergey *et al.*, 1923.
Phytomonas solanaceara (E. F. Smith) Bergey *et al.*, 1923.

Bacterium solanacearum has been reported as the cause of a wilt disease of tomatoes in St. Lucia (1904), St. Vincent (1917), and British Guiana (1925). In 1911, Rorer reported a bacterial disease of bananas and plantains occurring in Trinidad, which he attributed to *Bacillus musae* (19). What is regarded as the same disease has since been found by Ashby in Trinidad (2), and by Alston in British Guiana (1). Ashby however found that *Bacterium solanacearum* was the causal organism in both colonies, and is of the opinion that *Bacillus musae* and *Bacterium solanacearum* are synonymous. Although Ashby inoculated the bacterium he obtained from bananas into tomato and tobacco plants and obtained successful infection, there is no record previous to this paper of *Bacterium solanacearum* being pathogenic to tomatoes in the field in Trinidad.

Method of Infection and Control.

The chief source of infection is the soil in which the organism can live for at least two or three years. Where tomatoes are grown intensively the disease is controlled by sterilising the soil with steam, but this is not always practicable. The

* References will be published with concluding part of the article.

best means of control on a large scale is to employ a rotation which does not permit a susceptible crop (*e.g.*, tomatoes, egg-plants and tobacco) to be grown on the same land more than once in three or four years.

As the presence of diseased plants in the field often leads to secondary infection, they should be removed and destroyed as soon as possible. Various insects are capable of transmitting the disease, and the use of pruning knives is quite sufficient to carry the bacterium from one plant to another. The organism is probably a strict wound parasite, and the wounding of plants by implements and insects should be reduced to a minimum.

The planting of infected seed should be avoided as far as possible. The seed should be obtained only from healthy plants and, when necessary, should be disinfected before sowing. Suitable disinfecting solutions may be prepared by adding one part (by volume) of commercial Formalin to 320 parts of water, or by dissolving one part (by weight) of corrosive sublimate in 1,000 parts of water. The seed should be soaked in these solutions for about ten minutes and then laid out to dry before sowing.

At present there is no evidence of any variety of tomatoes being resistant to the disease.

Since the organism is one which can live for some time in the soil, an investigation into the influence of various soil properties on the life of the organism might lead to interesting results.

Fusarium lycopersici Sacc.

By far the most serious wilt disease of tomatoes occurring in tropical and sub-tropical regions of the world is caused by a fungus *Fusarium lycopersici*. This probably occurs wherever tomatoes are grown, but its incidence is restricted in the colder climates because the optimum temperature for its development is about 84° F. In Trinidad the disease is common, and occasionally so severe that it leads almost to the total failure of the crop. The fungus has been isolated from plants collected from Aripo, St. Augustine, Curepe, San Juan, and Diego Martin. In one instance the disease was found to be common in a field which had recently been reclaimed from bush.

Inoculation Experiment.

In October, 1931, an experiment was initiated to prove that the *Fusarium* sp. obtained in culture was pathogenic. Eight oil tins, each of four gallons capacity, were filled with soil and sterilised in the autoclave. On 14th October, 1931, the soil in tins Nos. 1 to 4 was inoculated with the mycelium and spores of the *Fusarium* sp. (Isolation XXIII), and immediately sown with tomato seed. Tins Nos. 5 to 8 were sown but not inoculated. Seed of the variety Bonny Best was used as this variety is one which is usually reported as being susceptible to *Fusarium lycopersici*. The soil in each tin was watered daily with sterile water. The number of plants which came up are recorded in Table I. By 16th November, 1931, the number of plants was reduced, chiefly owing to caterpillar damage. At the end of November the plants in the inoculated tins appeared to be stunted in general appearance when compared with those in the control tins, and a few plants were showing the later symptoms of the disease. On 12th December, 1931, the 44 control plants were still healthy. Of the 37 inoculated plants, 25 were apparently healthy, seven were wilting, and five were dead. The symptoms developed by the wilting plants were identical with those described below, and will not therefore be repeated.

Table I.

Tin.	I. Inoc.			II. Inoc.			III. Inoc.			IV. Inoc.			V. Control.			VI. Control.			VII. Control.			VIII. Control.		
	Healthy.	Wilting.	Dead.	Healthy.	Wilting.	Dead.	Healthy.	Wilting.	Dead.	Healthy.	Wilting.	Dead.	Healthy.	Wilting.	Dead.	Healthy.	Wilting.	Dead.	Healthy.	Wilting.	Dead.	Healthy.	Wilting.	Dead.
29th October	11	—	—	10	—	—	12	—	—	8	—	—	12	—	—	13	—	—	14	—	—	12	—	—
16th November	9	—	—	9	—	—	11	—	—	8	—	—	8	—	—	11	—	—	14	—	—	11	—	—
12th December	7	1	1	4	3	2	7	2	2	7	1	—	8	—	—	11	—	—	14	—	—	11	—	—
4 h January	1	3	5*	—	1	8*	5	—	6	4	—	4	8	—	—	11	—	—	14	—	—	11	—	—
8th January	—	4	5*	—	—	9*	4	1	6	4	—	4	8	—	—	11	—	—	14	—	—	11	—	—
15th January	—	1	8*	—	—	9*	4	1	6	4	—	4	8	—	—	11	—	—	14	—	—	11	—	—
28th January	—	—	9*	—	—	9*	4	—	7	4	—	4	8	—	—	11	—	—	14	—	—	11	—	—

* These numbers include wilting plants from which isolations were made.

Two wilting plants from tins Nos. 1 and 2 were examined. Hyphae were abundant in the vessels and the *Fusarium* sp. was re-isolated from each plant. The subsequent course of the experiment up to 28th January, 1932, may be seen from Table I. On this date only eight inoculated plants were living, and three of these were very stunted. As it was desired to terminate the experiment, three of the larger plants were taken to the laboratory for microscopical examination. Hyphae, typical of a species of *Fusarium*, were observed in the vessels of all three, but the fungus had not developed sufficiently to produce noticeable discolouration. The control plants were in the fruiting stage and still quite healthy.

From this experiment it is evident that the *Fusarium* isolated is the cause of the disease in the field. The symptoms as they occur and the morphological characters of the fungus are identical with those of *Fusarium lycopersici* Sacc., and it may be concluded that *Fusarium lycopersici* is present in Trinidad and is the cause of the wilt disease now under discussion.

Symptoms of the Disease.

Before the more typical symptoms of this disease develop, young plants usually acquire a stunted appearance. This condition is followed by a progressive wilting of the leaves, beginning with a leaf near the base of the plant. All or only some of the leaflets on the leaf may be affected at the same time, and they frequently turn yellow before they wilt. The wilting of a leaf is an indication that the vascular bundle or bundles supplying the leaf are infected, and this may be shown by the presence of a brown discolouration in the vessels when the stem is cut across in this region. If only one bundle is infected, then the wilting of the leaves takes place only on the corresponding side of the stem in order of their ages. If all the bundles are affected, however, the leaves wilt more or less in regular succession from the base of the plant upwards. A later symptom of the disease is the wilting of the head of the plant during the day, especially when exposed to a hot sun, followed by a recovery during the night. Further progress of the parasite soon produces a stage when the plant is no longer able to make this recovery, and death occurs in a short time.

Life History of the Fungus.

Fusarium lycopersici is an organism which is capable of living in the soil for a number of years even in the absence of its host. Some soils, however, are much more suited to the development of the fungus (as shown by the incidence of disease) than others. Sherwood has shown (20) that the percentage of wilt decreases uniformly with a reduction of the acidity of the soil until the soil is about neutral. Edgerton and Moreland (9) and others have found that the amount of wilt on acid soils is decreased by applications of lime.

Clayton (6) has found that infection depends to some extent on soil humidity. In his experiments plants grown in soil with a low moisture content (13 to 19 per cent.) were little affected by the disease, while those grown in saturated soil (35 per cent. moisture) were not infected.

Soil temperature has a marked influence on the pathogenicity of the fungus. The work of Clayton (7) shows that the optimum soil and air temperatures for heavy infection are 27° and 28° C. respectively.

Dissemination of the organism takes place very largely by sowing infected seed. There is evidence that in some cases the mycelium of the fungus may be present inside the seed, as well as simply adhering externally to the seed coats (10).

The fungus enters the plant through the roots, and quickly invades the vessels in the vascular bundles of both the root and the stem. In response to the presence of the parasite, brown gum is deposited in the invaded cells, probably in an attempt to form a barrier. This brown gum may be seen macroscopically when the stem is cut across in the invaded region. Occasionally the mycelium enters the vascular system of the fruit and causes infection of the seed (10). If infected plants are left in the field to decay the organism is again returned to the soil.

Control.

The control of *Fusarium lycopersici* in a country where little work has been done on the disease is a difficult problem. This fungus, like many others, exists as a large number of different strains which differ in morphological and physiological characters (14), (24). Certain varieties of tomatoes when grown in certain districts are known to be resistant to the strains of the organism which occur in that district, but when these varieties are subjected to the attack of strains in another district, they may become very susceptible. Varieties which have proved resistant in the United States include Marglobe, Louisiana Pink, Louisiana Red, Norton, Marvana, Kanora, and Norduke (23), (25), while two of the most susceptible varieties are Bonny Best and Stone. In Trinidad, varieties resistant to the local strains of *Fusarium lycopersici* have not yet been determined, but an attempt is now being made by growing a number of varieties on infected soil. Until resistant varieties have been ascertained, the control in the field depends on field management and sanitation. A rotation should be used which does not permit frequent planting of tomatoes on the same land. As soil acidity favours the disease, the application of lime to acid soils would prove beneficial (9). Infected plants should be removed and destroyed as soon as possible, and not left to decay in the field.

As seed from diseased plants is liable to be infected, care should be exercised in obtaining it from healthy plants. By planting clean seed in a sterilised or disease-free seedbed, infection would at least be delayed for about a month, and perhaps avoided altogether.

Under greenhouse conditions, the disease may be controlled by the steam-sterilisation of the soil (2). Advantage may also be taken of the fact that a reduction in temperature below 27° C. reduces the virulence of the organism, and if the disease occurs, the temperature of the greenhouse is decreased. These methods however cannot be utilised in Trinidad, since tomatoes are grown in the field.

Sclerotium rolfsii Sacc.

The third type of wilt disease which occurs on tomatoes in Trinidad is caused by *Sclerotium rolfsii* Sacc., and is commonly known as "Sclerotium Wilt". Under favourable conditions the fungus is a virulent parasite not only on the tomato, but also on a large number of other host plants, some of which are woody perennials. Its distribution appears to be fairly general throughout the tropics and sub-tropics. In Trinidad it has been found on tomatoes and on other hosts in several districts, and was very prevalent on tomatoes in the Diego Martin Valley during the dry season of 1931. In some of the fields visited, more than 50 per cent. of the tomato plants were wilting, and on about 90 per cent. of these the characteristic sclerotia of the fungus were present.

Symptoms.

The first indication that a plant is attacked is a wilting of the leaves such as would happen if the stem had been completely severed at ground level. The leaves undergo no preliminary discolouration before they droop. Whole or partial recovery may occur under favourable conditions which retard transpiration (*e.g.*, at night) but the leaves droop again very quickly when the conditions are reversed. When the wilting has progressed so far that the plant is unable to make this recovery, death of the plant quickly takes place.

Sclerotium rolfsii generally attacks the plant near ground level, where the stem is usually killed. The mycelium of the fungus may frequently be seen as a white feathery growth encircling the stem for a distance of three or four inches above the level of the soil. This mycelium later gives rise to numerous sclerotia. When very young (about a quarter of a millimetre in diameter), the sclerotia are whitish in colour and are attached to the mycelium by a small white stalk. As they increase in size, the colour gradually darkens to a purplish-brown. The mature sclerotia are somewhat spherical in shape, and usually measure about one to one and a half millimetres in diameter. To a casual observer they would very much resemble mustard seed in appearance.

Bertus (4) in Ceylon found that when he placed the mycelium or the sclerotia of *Sclerotium rolfsii* in contact with the unwounded roots of tomato plants, the collars of the plants were attacked but the roots were not infected. Although this may be so, there are indications in Trinidad that infection of the roots does sometimes take place when the soil is very dry.

Infection of other parts of the plant (*e.g.*, fruit) is liable to occur if they are in contact with infected soil.

Reproduction of the Organism.

Sclerotium rolfsii is one of the very few fungi which is not known to produce spores. Reproduction therefore apparently depends entirely on the germination of sclerotia, which occurs as soon as moisture and other conditions are favourable. The sclerotia are able to withstand desiccation for several months. They are not dispersed by wind, and dissemination depends on their being carried by other agencies. The mycelium of the fungus grows very quickly and plants may wilt within four days of becoming infected.

Control.

The control of this disease depends chiefly on proper field sanitation. Infected plants should be removed from the field and destroyed as soon as possible, either by burning, or by burying them two or three feet in the soil. If the plants are left until sclerotia have had time to develop, re-infection of the soil may occur. Attention should also be paid to drainage and tillage, so that the moisture-content of the soil is kept as constant as possible.

Cladosporium fulvum Cke.

The affection caused by *Cladosporium fulvum* is popularly known as leaf-mould or leaf-rust of tomatoes. It occurs in Trinidad and probably in all countries where tomatoes are grown. The prevalence of the disease has been shown to depend on atmospheric temperature and humidity. In temperate regions it causes serious damage to tomatoes grown in greenhouses, and in the tropics and sub-tropics it attacks plants in the field.

Symptoms.

Although *Cladosporium fulvum* in some countries causes a disease of the stem, leaves, flowers and fruit, in Trinidad it occurs only on the leaves. The disease generally appears first on the oldest leaves, which are near the ground and therefore under humid conditions. Plants growing in sheltered positions are specially liable to be attacked. The disease is usually first noticed by the occurrence of yellowish spots one-eighth of an inch or more in diameter on the upper side of the leaflets. Later these enlarge and turn bright yellow. On the lower surface of the leaflets and corresponding with the spots on the upper surface, there develop patches of velvety greenish-brown fungus growth, which darken with age. From these patches masses of spores are liberated, which are readily disseminated by air currents. After a few days the infected portions of the leaf are killed and turn brown. Under suitable conditions both old and young leaves are infected.

Conditions affecting the Disease.

By investigating the disease under greenhouse conditions in England, Small (21) has shown that the optimum temperature for the various stages is about 72° F. At this temperature primary infection is severe at 80 per cent. humidity, and decreases as the temperature is reduced. He believes that a film of water on the leaves is not necessary for infection to take place, and states

that the persistence of damp conditions for four hours each night is liable to cause heavy infection. Under optimum temperature conditions, infection was rare at 70 per cent. humidity and at 66 per cent. progress of the disease was very slow.

When the atmospheric humidity is very high and there is little or no air movement, transpiration by the leaves will quickly increase the humidity of the atmosphere in immediate contact with the leaf surfaces to a point of saturation, and to a condition very favourable for fungus growth or spore germination. When, however, the leaves are subjected to a current of air the saturated atmosphere around the transpiring leaves is more quickly dispersed and infection is reduced. It has been shown (16) that even when the humidity is as high as 85 to 90 per cent. the disease may be controlled by rapidly changing the air around the plants through artificial means.

Control.

As the disease incidence is closely correlated with temperature and humidity conditions, and in Trinidad the temperature varies very little with the different times of the year, the control of the disease in the field depends largely on growing the plants when and where atmospheric humidity is low. Sheltered positions should be avoided. The free circulation of air around the plant may be promoted by staking, pruning, and by allowing sufficient space between the plants. The use of copper sprays has proved advantageous in some countries, and might be worth while when rainfall is not too frequent. The occurrence of varieties of tomatoes resistant to this disease has lately received attention in England (21) and the United States.

Septoria lycopersici Speg.

This fungus is the cause of a leaf disease of tomatoes which is widely distributed in tomato-growing countries. It is very serious in the Middle Western and Middle Atlantic States of America, and has been reported as one of the chief obstacles in tomato cultivation near Buenos Aires (Argentine). Infection results in the spotting of the leaves, petioles and stems, which may be so severe that the plants are almost completely defoliated. It has been estimated that the average annual loss due to this disease in the United States is in the neighbourhood of 250,000 tons of fruit. In Trinidad the disease is fairly common, especially during the wet season, but is rarely severe enough to cause much defoliation.

Isolation and Inoculation Experiment.

The fungus has been isolated from leaf spots on several occasions, and was found to spore well on sterilised maize stems.

An inoculation experiment was carried out on six tomato plants about 15 inches high, which were growing singly in tins. From one of the cultures, a spore suspension in sterilised water was made, and by means of an atomizer, this was sprayed over three of the plants. Each of these plants was then covered with a bell-jar. The other three plants were sprayed with sterile water only, and similarly covered. After 36 hours, bell-jars were removed from one of each of the inoculated and control plants. Twenty-four hours later the remaining plants were uncovered. By this time, all the inoculated plants were seen to be infected. Small brown spots were present on all the leaves, and occasionally on the petioles and stems. Later these spots enlarged and produced the characteristic pycnidia and spores of the fungus, and the latter was re-isolated. A photograph of a diseased leaf and petiole from one of the plants is shown in Fig. IV. No symptoms of the disease were developed by any of the control plants.

Symptoms.

The first signs of the disease usually appear on the oldest leaves. The young spots take the form of small brown water-soaked areas, visible on either surface of the leaf. These areas enlarge until they attain a diameter of about an eighth of an inch. By this time, the leaf tissue in the centre of the spot is light brown in colour, and is surrounded by a darker margin. No concentric zonation is apparent. The spots are usually oval or round in outline, but if a leaf is badly infected several spots may coalesce to produce irregularities in both shape and size. On the light coloured centres of the spots a number of small black specks, which are the fruiting bodies or pycnidia of the fungus, can usually be observed. Severe infection results in the ultimate death of whole leaves which turn brown and hang vertically from the plant. Although leaves near the ground are usually the most attacked, the damage is not by any means confined to these, and in countries where conditions are appropriate serious defoliation is the result.

Factors influencing Disease Incidence.

Reproduction of the disease occurs by the dissemination and germination of spores, which are produced in the pycnidia. Abundant spore-production has been found to take place when the fungus is grown on various culture media such as sterilised stems of cotton, clover, corn, grasses, &c. It is therefore quite probable that the parasite can live and fructify naturally on the dead tissue of various plants in the field. The life history is further complicated by the fact that the organism is a parasite on various other hosts, *e.g.*, potatoes, egg-plants, and various other members of the *Solanaceae*.

In America, Pritchard and Porte (17) have found that there is a considerable relationship between the incidence of disease caused by *Septoria lycopersici* and the temperature of the tomato-growing regions. The chief development occurs in a temperature belt of 73° F. to 78° F. This range of temperature is in the neighbourhood of where the optimum range of temperature for

the growth of the fungus (54° F. to 82° F.) overlaps the optimum range for growth of the tomato plant (77° F. to 86° F.). They also found that sporulation on culture media only occurred at temperatures between 59° F. and 80.5° F., the optimum being 77° F.

The relation of humidity to spore germination and infection has apparently not been determined, but no doubt such a relationship does exist. It has been shown by Stair, Brown, and Hienton that plants growing in hot-beds could be protected from infection by *Septoria lycopersici* by means of forced ventilation (22). This would naturally decrease the humidity of the atmosphere in contact with the leaf surfaces by constantly removing the water vapour transpired from the leaves.

Control.

In America partial control is obtained by growing early crops so that the temperatures most favourable to spore production and disease incidence are to some extent avoided. This is impossible in Trinidad where the temperature varies very little throughout the year, and rarely falls below 62° F.

Humid conditions should be avoided as much as possible, by selecting the sites for planting, by growing plants to mature in the dry season, and by encouraging ventilation around the plants by proper spacing and if possible, staking.

Field sanitation is also important. Old tomato plants and wild plants which are likely to be infected by the organism should be removed and destroyed by burning, or by burying them deeply in the soil.

Spraying with Bordeaux mixture or with other copper sprays has been recommended in other countries, but it must be done before the disease becomes serious, and repeated as often as is necessary to keep the plants covered. Under tropical conditions, good quality quick-lime which is necessary for the preparation of Bordeaux mixture, is very difficult to obtain. The constituents of Burgundy mixture, however, are universally procurable. The latter is an excellent fungicide and adheres as well as Bordeaux mixture to plants subjected to showers. It should be used at a strength of 4. 5. 40. (4 lb. copper sulphate crystals, 5 lb. washing soda (crystallised sodium carbonate), and 40 galls. water).

Phoma destructiva (Plowr.) C. O. Jamieson.

This fungus is widely distributed, and is probably present in all tomato-growing countries. The damage produced by the organism is usually confined to the fruits, which it attacks only as a wound parasite. In the United States however, as shown by Jamieson (12) the fungus is an active parasite on the leaves and stems as well as on injured fruits. This is also the case in Trinidad where it is the cause of by far the most serious leaf spot disease of tomatoes. It is prevalent in both the wet and dry seasons. Not only does it attack mature plants, but it causes considerable damage to seedlings in the nursery, killing most of the leaves, and producing serious lesions on the stems.

The fungus has been isolated by the writer from spots on leaves, stems, and fruit. The morphological characters of the fungus and its effects on the host form conclusive evidence that *Phoma destructiva* (Plowr.) C. O. Jamieson is involved. The following inoculation experiment was carried out to prove the pathogenic character of the organism.

Three plants about two feet high were sprayed with a suspension of the spores in sterilised water, and covered with bell-jars. Three other plants were sprayed with sterile water only, and similarly covered. After 42 hours, one control and one inoculated plant were uncovered. Twenty-four hours later the leaves, petioles, and stems of the inoculated plant were infected in a number of places. The remaining bell-jars were consequently removed, and the second and third inoculated plants were then found to be very badly infected. Every leaf from the youngest to the oldest, the stems, and petioles were covered with small, irregular, blackish-brown spots. As many as 50 spots were present on a single leaflet. On the sixth day the leaf-spots were about ½ to 2 mm. in diameter (Fig. V) and a few days later about three of the oldest leaves on each plant were shrivelled and hanging vertically from the stem. Numerous pycnidia of the *Phoma* were observed by a microscopical examination of the mature spots, and the organism was again isolated and obtained in culture. All the controls remained healthy throughout the experiment.

Symptoms.

This disease attacks plants of all ages, and although most frequently observed on older leaves, it will attack quite young tissues. The young spots on the leaves are brown to almost black in colour, irregular in outline, and visible on both surfaces. They enlarge rapidly, usually becoming more definite in outline and developing signs of concentric zonation. The margins of the leaves seem specially liable to attack. The presence of several spots on the same leaflet frequently cause it to turn yellow and die. Thus, in the case of severe infection, many leaves are killed, and hang vertically from the stem for a considerable time. On the dead tissue in the middle of the spots the pycnidia or fructifications of the fungus are produced in large numbers. As they are small and immersed in the host tissue, they are very difficult to observe with the naked eye. Spores are exuded from the pycnidia in long streams, or coils.

The disease is sometimes very destructive to plants in the nursery, both on leaves and stems. The leaves are frequently killed before they have fully expanded with the result that practically nothing but the bare stem of the plant remains.

The lesions on the stem are blackish-brown in colour, generally elongated, but irregular in outline. The coalescence of several spots may produce blotches two or three centimetres in length and completely girdling the stem. If the plant is not then killed, the stem remains somewhat constricted at this point, owing to the growth in circumference being retarded. On older stems and petioles, the lesions usually resemble elongated streaks, although on the former they seldom are more than a millimetre long.

The symptoms of the disease on the fruit are discussed subsequently.

Control.

No satisfactory method of control is known. The procuring of clean seed, and the use of a good rotation are recommended. In Trinidad where tomatoes are grown all the year round, it is very easy for diseases to travel from one field to another, and old plants should be destroyed as soon as they have finished bearing. Very damp situations should be avoided as much as possible, and everything done to encourage a free circulation of air around the plants. In America spraying with Bordeaux mixture or with other copper sprays is frequently recommended, and this might be very advantageous during the dry season. In the wet season, the frequent removal of the spray by rain, coupled with the low yield at this season form strong arguments against spraying.

Mosaic Disease.

Mosaic disease of tomatoes which is caused by a "virus", probably occurs wherever the crop is grown. In Trinidad at certain seasons of the year, small plots and gardens are so severely infected that the crop is almost completely destroyed. On the other hand large fields are frequently seen in which the disease does little damage. The symptoms vary considerably, and may be separated into several different types. One type consists of a simple mottling of the leaves, with little reduction in the amount of fruit produced. Occasionally however, the plants are very stunted, and show a profuse development of young pale shoots. The petioles are very long and distorted, and bear thick malformed leaflets which vary considerably in size. The fruiting capacity of these plants is usually destroyed. Plants with symptoms resembling those of Aucuba mosaic have also been noticed. Up to the present time little attention has been paid to the disease in Trinidad, but it is hoped that investigations will be carried out shortly.

Heterodera radicicola.

This nematode is of common occurrence in the roots of tomatoes in Trinidad. The symptoms consist of the formation of gall-like swellings on all parts of the root system and the consequent stunting or death of the plants. The eelworm is important not only because of its direct effect on the plant, but because its injuries to the root system probably make the plant more susceptible to the attack of other organisms.

(*To be concluded.*)

WASTE MATERIAL.

Utilisation of Vegetable Waste Material.

A LONDON company called the Residual Products Transforming Syndicate, Ltd. has been incorporated for supplying the machinery for the Freeman Transformation Process. This process claims to obtain from the residues of vegetable material readily marketable chemicals, together with carbon and gas. Of the various vegetable substances treated, the following have offered the largest and most profitable fields :—sugar-cane residue (bagasse), banana leaves and stalks, coffee husks (pergamino), sisal and tobacco waste, and coconut shells. The materials obtained from these are acetic acid, acetone, alcohols, furfurol, dye-bases, germicides, insecticides, and sometimes essential oils, leaving a residue of marketable charcoal, and producing combustible gases which can generally be utilized.

Five tests on three different coals were carried out by the Director of Fuel Research of the British Department of Scientific and Industrial Research, and the following quotation from the report is included in the company's illustrated brochure :—

"The amount (of oil-yielding liquid) collected during the tests is of the order of ten per cent. higher than has been obtained in tests carried out by the Fuel Research Staff using bituminous coal in other types of low temperature carbonising plants.

"The 'Kirkby Top Hard' and the 'Brynna' coals show approximately a 20 per cent. increase (in oil-yielding liquid) when treated in the Freeman Retort, as compared with the horizontal steel retorts (in use at the Fuel Research Station at East Greenwich)."

The process gives the following yields :—

Sawdust, per ton : Acetic Acid, 34 lb. ; Alcohols, 50 lb. ; Turpentine, two gallons ; Carbon Residue, 850 lb.

Papyrus or "Sudd" from the Nile, per ton ; Acetic Acid, 97 lb. ; Acetone, 39 lb. ; Methyl Alcohol, 48 lb. ; Heavy Alcohol, 68 lb. ; Furfurol, 68 lb. ; Carbon Residue, 676 lb.

Sugar-Cane Residue (Bagasse) from Java, per ton ; Acetic Acid, 128 lb. ; Acetone, 49 lb. ; Methyl Alcohol, 118 lb. ; Furfurol, 39 lb. ; Carbon, 746 lb.

Banana Leaves and Stalks, per ton ; Acetic Acid, 60 lb. ; Acetone, 161 lb. ; Furfurol, 362 lb. ; Methyl Alcohol, 100 lb. ; Carbon, 921 lb.

Coffee Husks, per ton ; Acetic Acid, 144 lb. ; Acetone, 51 lb. ; Ethyl Alcohol, 115 lb. ; Heavy Alcohol, 57 lb. ; Essential Oils, 28 lb. ; Carbon, 672 lb.

According to the approximate costing data, the process is profitable, and further information may be obtained from the company at Portland House, 73, Basinghall Street, London, E.C. 2.

D. W. D.

MAIZE IN KENYA.

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Introductory.

It is said that maize was introduced into Africa several centuries ago by Portuguese traders and slave-raiders and that it was brought into that part of East Africa, now known as Kenya Colony, through the same agencies, especially as Mombasa, the chief port, was formerly a Portuguese town. Maize grown in some of the Native Reserves is mixed with red and purple grained types which are similar to types grown by American Indians at the present day and it is very probable that this dark-coloured variety is a survival of very early introductions. Since this admixture of types is prejudicial to an export trade in native-grown maize, efforts have been made to supply the Reserves with seed of suitable white maize.

The maize which is chiefly grown in the settled areas is the result of former introductions from South Africa (where the crop was already firmly established) made by the Department of Agriculture, especially in 1907, and also by farmers. These South African varieties were, of course, adapted forms of American varieties which had been introduced at various times from the United States of America. Among the varieties which were brought into Kenya may be mentioned "Hickory King", "Natal White Horsetooth", "Ladysmith White", "Iowa Silver Mine", "Champion White Pearl", and "Potchefstroom Pearl". The ordinary "Kenya Flat White" maize is a hybrid which owes much to "Natal White Horsetooth" and "Hickory King". This type is chiefly grown for export over practically the whole acreage devoted to maize in the Colony. "Chester County Mammoth" and "Yellow Hogan" have been introduced, but little yellow maize is grown in the country, as, despite the superior nutritive value of yellow maize-meal, farmers are afraid of the crossing of their white maize with yellow, and of a consequent depreciation of the value of their crop as an exportable commodity. Also, for certain purposes, "Flat White" maize commands a premium over "Yellow". Almost the whole of the "Flat White" maize imported into Europe comes from Africa.

* Harrison describes the growth of the export trade as follows: "In 1910 small consignments were sent to England and a trade sprang up with near-by markets. Railway rates were considerably reduced and some 20,000 bags were sold in Europe. The necessity for the inspection of this product was recognised. The consignments were examined prior to shipment. The crop was found to be very free from disease and insect pests and increased in favour.

Exports in 1912-15 amounted to 115,000 bags (200 lb.) much of this came from Nyanza, and attempts were made to induce buying agents to pay a higher price for a better class of maize.

In 1913-14 a big improvement in the standard of quality of maize was noticeable and London reports showed that the Protectorate was capable of producing maize equal in quality to that of other maize-producing countries, and high average yields were obtained. During the war the outturn was reduced, but afterwards export developed on a considerable scale. In 1923, 500,000 bags found their way to the London market."

The table below gives the production and export of maize from Kenya for the last eleven years together with other related data.

The crop constitutes the most important part of native diet both in the Reserves and in the Settled Areas, the usual ration for a labourer being two lb. of maize meal per diem. It is difficult to estimate the native production and hence the internal consumption of maize in the Colony. In 1929-30 it was estimated that 386,310 acres were planted by natives and that 1,387,104 bags of 200 lb. were harvested which represents an average production of 3.59 bags per acre.

Year.	From Agricultural Census.		From Customs Returns.		
	Acreage harvested July-June.	Total European production. (bags of 200 lb.).	Yield per acre (200 lb. bags).	Quantity exported in bags of 200 lb.	Value. £
1919-20	32,167	317,525	9.87	164,058	101,480
1919-21	30,846	164,722	5.34	75,287	47,995
1919-22	57,131	338,837	5.93	50,267	41,995
1919-23	74,747	517,877	6.93	467,268	255,064
1919-24	108,556	833,640	7.68	642,681	351,331
1919-25	129,647	893,108	6.89	682,663	437,508
1919-26	155,751	826,614	5.95	477,147	271,815
1919-27	177,987	1,314,643	7.39	1,100,708	556,027
1919-28	177,009	1,088,706	6.15	450,845	293,118
1919-29	204,945	1,099,317	5.36	511,034	365,120
1919-30	233,973	1,858,586	7.94	800,293	405,613

* Harrison, E. "Maize in Kenya." *Bulletin No.* 7, Department of Agriculture, Kenya, 1926.

Out of the total export of 1,429,094 cwt. in 1929-30 the following amounts were taken by various countries :—

Great Britain	956,290	cwt.
U.S.A.	402,885	do.
Holland	268,261	do.
Belgium	180,805	do.
France	178,737	do.
Tanganyika	60,775	do.
Germany	47,116	do.
Portugal	40,000	do.
Italy	25,004	do.
Socota	18,855	do.
Zanzibar	4,477	do.
Italian E. A.	3,138	do.

Great Britain is always the best customer for Kenya maize. This year was the first in which the United States of America, owing to a partial failure in the American crop, imported Kenya maize. Holland and France also imported larger quantities of Kenya maize than formerly. Kenya maize is bought by larger importing countries chiefly for the manufacture of cornflour, starch and whisky.

In 1918 at Nakuru a farmer's association was formed for the purpose of marketing co-operatively maize grown by its members, and for the easier purchase of farm requirements. This association has since expanded; it amalgamated in 1927 with the Plateau Maize Growers Association, so that it now includes, under the title of the Kenya Farmers' Association, about 95 per cent. of the maize growers in Kenya Colony.

Climate.

The greater part of the maize crop in Kenya is grown in the Highlands between altitudes of 5,500 and 6,500 feet. Thus the climate is sub-tropical rather than tropical, with the maximum temperature generally varying in the different districts between 80°F. and 90°F., and the minimum between 45°F. and 55°F.

As the Equator passes through Kenya Colony the length of day which is only about twelve hours differs very little throughout the year. Owing to this fact, Kenya maize grown in one of the two large maize-growing areas, namely, the Trans Nzoia or the Nakuru district, needs eight to nine months to mature. This compares with a growing season for maize of a little over four months in the chief maize districts of the United States of America. Small quantities of maize are grown even up to 8,000 or 9,000 feet where it may then take 12 or 13 months to mature. Under these latter conditions cold nights with temperatures often considerably below 40°F. also play a part in retarding the growth of the crop.

Introduced American maize varieties tend to preserve their original physiological "rhythm" without making sufficient growth before drying. Thus some "Dakota White Flint" introduced in 1931 and planted near Kitale was in full tassel and silk and had attained a height of six inches to two feet six inches sixty days after planting. Maize which has been grown in South Africa, even though it first came from America, and is then introduced into Kenya has undergone preliminary adaptation and is by no means such a failure as directly imported maize, but is nevertheless ill suited at first to the climatic peculiarities of the Colony.

On the whole, the Nakuru district is drier than the Trans Nzoia, the average annual rainfall being roughly 35 to 40 inches as compared with 40 to 50 inches, or even 60 inches or more in some districts in the latter area. Thus a relatively wet season is more favourable to the Nakuru area, while maize in the Trans Nzoia may suffer deterioration from excessive moisture. In the abnormally wet year of 1930, the yield within Nakuru district was estimated at an average of 9.58 bags per acre, while the Trans Nzoia figure was only 7.9 bags. This compares with 7.58 bags per acre for Nakuru in the drier year of 1929-30, and 9.25 bags for Trans Nzoia.

Soils.

The largest maize growing region is the Trans Nzoia, where the area under maize in 1930 was 80,205 acres. This district has developed rapidly of late years since the making of a branch line in 1927 between Eldoret, the capital of the Uasin Gishu province, and Kitale. Up till 1925, the Trans Nzoia was handicapped considerably by the fact that Kitale, its port, is about 125 miles from the rail-head which was then Londiani, now an unimportant village. The second largest growing district is the Nakuru district whose area is 70,910 acres. The Uasin Gishu contributed 36,189 acres and other smaller regions an aggregate of about 20,000 acres.

The soils of the Trans Nzoia region are typically red sandy soils with an acid reaction, while on the poorer lands, the sub-soil is increasingly and dangerously acid. The colour of the soil varies with the humus content. The richer soils on the Kitale Plains and around Mount Elgon are of different origins and their much darker colour is associated with a higher lime content.

The soils of the maize districts in the Nakuru area vary considerably in kind. Those in the Lower Molo and Rongai areas are comparatively old and are red loams. As the Menengai Crater is approached, this red soil becomes overlaid with recent volcanic material consisting of grey decomposed volcanic ash layers separated by layers of tuff. At the higher altitudes, further from the Crater, the surface soil is derived from older rocks, and is of a pinkish-grey colour with undecomposed lava several feet below the surface.

Methods of Cultivation.

Ploughing.—After harvesting, the old stalks are gathered together, either in rows or in heaps, and burnt, a procedure which is carried out principally to facilitate good ploughing. In many cases about one month elapses between the removal of the old stalks and the planting of the succeeding crop; four months is the maximum time which is generally allowed for rotting down of the maize stalks if ploughed under early. Decomposition is slow in a dry soil, and it is found that the crop-residues do not decay quickly but

remain as trash which keeps the soil open but impedes the various operations of planting and cultivation. Furthermore, the analysis of dry maize stover shows a low content of nitrogen, so that bacteria responsible for the decomposition of its carbonaceous components draw upon the nitrates in the soil for their nutrition ; nitrification not becoming dominant until the carbon nitrogen ratio has been sufficiently reduced. This temporary destruction of soil nitrates has a prejudicial effect on the growing crop, as has been pointed out by Gracie (1), especially where, as in most Kenya soils, humus and nitrogen, are not abundant. Gracie also states that "the duration of the adverse effect resulting from this" (that is, the ploughing under of the dry straw of the previous crop) "although longer in very acid soils is in all cases temporary, and the humus eventually formed from the straw will result in an increase of soil fertility. However, the loss in crop in the first year is never compensated for by the increased crop in the second year".

It must be admitted, however, that the practice of burning stalks eventually results in the loss of much humus from the soil, not only through the destruction of the stalks themselves, but through the charring of organic matter already in the soil. This loss has already caused considerable deterioration of many of the maize soils in Kenya Colony which, except for some rich forest soils, for example, around Mount Elgon, were somewhat lacking in humus even in the virgin state. Nevertheless the question of pests and diseases is so grave under the "one crop" system that at present the policy of removal and burning of all dead "trash" has to be continued, and the requisite humus must be supplied by green manuring and by farm-yard manure where available.

The ear, root, and stalk rots of maize have been shown during the last year or so to be so serious that the officers of the Department of Agriculture are advising the complete removal of the roots and base of the stalk by the use of a short "couch-fork", provided with teeth set at right angles to the handle, rather than by cutting off the stalk just above ground with a "jembie" or short hoe as was previously the general custom. In the Nakuru area, the complete destruction of stalks is additionally desirable on account of the prevalence of the "Stalk Borer" moth, the pupa of which is found in the maize stalks.

Experiments are being carried out to ascertain whether maize stalks may be turned into artificial manures by processes (*e.g.*, the Adco method) which are both cheap and safe in so far that the heat generated by the chemical changes involved leads to the destruction of the spores and mycelia of fungi.

A disc harrow is subsequently taken over the old maize fields or "shamba" in order to cut down weeds which may have appeared during the withering of the maize foliage, and to cut up any stray stalks which may have escaped burning.

If the work is well advanced, the farmer may now plough the land (November to January), and perhaps plough again just before planting (February or March) or—more usually—he will merely apply a disc harrow to freshen the soil and to destroy seedling weeds preparatory to sowing. If the harvest was late, the farmer may plough only once in February or March. Where the ploughing is done early, the farmer will often disc harrow across the furrow in order to pack the soil to avoid excessive exposure to the hot sun of the "dry season", and to assist rotting down of weeds. In all cases a tooth or spring-tined harrow is used to reduce the tilth before sowing and to remove any remaining trash which may block the planters or smother the young maize plants as they emerge from the soil.

Where scouring is good, a mould board plough is often preferred, but disc ploughs are more generally employed. Disc ploughs are cheaper to use since they suffer less wear, especially in the sandy soils, in which discs will get over small boulders or stumps that would break the share points of mould board ploughs. On the other hand, mould board ploughs can be made to do better work in covering weeds and producing an even tilth.

A ploughing depth of five to eleven inches may be employed according to individual taste or circumstances. During the last few years a considerable return to ox-cultivation has been witnessed in an endeavour to reduce costs, teams of sixteen oxen being generally used for ploughing. The larger estates, are, however, obliged to retain tractors to assist in the ploughing. At the same time, no maize farm can be completely "mechanised" as oxen are needed for inter-cultivation.

Planting.

While there is a general tendency for agriculturists all over the world to become more dependent on machinery than heretofore, it is curious that the Kenya farmer is reverting more and more to hand labour both for planting and cleaning. The necessity for increasing yields by obtaining an adequate density of plant population, and thereafter by maintaining a good standard of cleanliness, has been repeatedly impressed upon the Kenya maize growers by the Plant Breeding Services of the Department of Agriculture (3 and 4). It was found that a sufficient stand of plants was more easily obtainable by hand planting (4) than by other means. As cheap, although not highly efficient native labour is still obtainable the hand-planting methods have been adopted enthusiastically by many of the best farmers in the Colony, some of whom state that by planting 40 acres a day and employing 25 boys, they can plant more cheaply than by machine. In order to facilitate thinning out by the natives, and to expedite planting, it is customary to plant in hills, at such spacings as 36 inches by 36 inches (two plants per hill), 42 inches by 28 inches (two plants),

41 inches by 42 inches (three plants per hill), &c. Experiments are being carried out to ascertain whether there is any material loss in yield through hill-planting as opposed to row-planting. A mechanical attachment has been devised recently by a Kenya farmer by which an ordinary maize planter can be made to plant in hills. This is said to give as good results as hand-planting and the mechanism was used extensively by farmers in 1931.

As the result of experiments and field censuses carried out by the Plant Breeding Services in 1930, it appears preferable, *where an ordinary planter is still used*, to plant at 42 or 44 inches by 14 or 15 inches (one plant per hill) though individual soils may necessitate other spacings. This ideal spacing is generally attained by planting at seven or eight inches, and subsequently thinning by chopping out some of the more weakly plants with a hoe or with a "panga" (a tool similar to the West Indian cutlass).

The importance of selecting seed free from disease is now well appreciated by Kenya maize farmers. Grain of a somewhat hard "flinty" appearance is recommended in preference to the soft starchy type which is found both in Kenya and in the United States of America to be more susceptible to ear and root diseases. Seeds from cobs with clean white cores and free from discoloured grains are favoured. The use of seed-disinfecting dusts is spreading amongst the farming community.

Planting commences generally with the onset of the Monsoon rains or long rains occurring at the end of March. In the Trans Nzoia region, planting may start as early as February during the preliminary rains. Planting after May produces inferior results. Both in the Nakuru district and the Trans Nzoia, all maize planting should ideally be completed during March and April, but in Trans Nzoia earlier planting is the practice, as it is necessary to plant maize while the soil is still warm after the short dry season. The onset of the rains varies from year to year, and with it, the time for planting. Many farmers claim that, where "cutworm" has not been a serious pest, they have had excellent results from "dry-planting" two or three weeks before the break of the long rains.

Cultivations.

It is good practice to harrow over the planted maize about five days after planting, in order to destroy young weed seedlings. Tooth-harrows and walking-weeders may be used to good purpose for several weeks after germination, though it is advisable to use these implements only when the sun is well up and the stalks are flaccid. This is particularly important when the maize is older. Afterwards, single cultivators are used which are pulled either by two oxen in a double yoke, walking in the rows on either side of the row being cultivated, or by a single ox. Chisel tines are used first for deep cultivation, and afterwards "A" blades for shallow cultivation. Two to four of these cultivations are given normally during the course of a season, ceasing when the growth of the maize prevents the passage of the oxen. One or two hand cleanings are also customary on the better farms. The custom of using ridging cultivators in maize fields has been condemned by the Department of Agriculture as leading to a slovenly standard of cleanliness and to harm through cutting the maize roots extending across the rows. All cleaning of maize is expected to end by tasselling time.

Harvesting.

The maize cobs are either picked straight off the field, when the crop is sufficiently dry, or the stalks are first cut or pulled and stooked in large stooks which are placed in rows, permitting the use of disc harrows and ploughs on the inter-rows. Time so saved is a great asset in maize farming in Kenya. Some farmers state on the other hand, that stooking is to be deprecated as leading to a more rapid spread of disease and weevil in the cobs, especially when heavy rains fall upon the corn.

Shelling is sometimes done directly in the field, light portable shellers often being carried along the rows, after the cobs have been husked and thrown in heaps to dry-out upon maize stalks laid on the ground. This procedure provides a close season free from weevils which otherwise multiply in the stores. More commonly the harvested cobs are carted by ox-wagon to large permanent cribs furnished with iron roofs and wire netting sides, and having a capacity of about 1,000 bags.

During the past few years, the use of temporary cribs has become more prevalent. These are small circular bins of capacity of about 300 bags, having walls and roofs made of wooden posts and fencing-wire, upon which are woven maize stalks together with grass, thus providing barriers sufficiently durable to keep out rain for the few months intervening between harvest and the time at which the maize is shelled and despatched from the farm.

Subsequently, the poles are removed to a fresh clean site and the remaining portions of the crib are burnt on the spot, ensuring the destruction of any weevils which may be harboured in the materials.

Pests of Maize in Kenya and their Control.

(*a*)—*Insect Pests.*—The chief insect pests are Cutworms, Ear-Worms, Stalk-Borers and Weevils.

The known species of Cutworm in Kenya are:—*Euxoa segetis*, Schf., *Euxoa spinifera*, Hubn., *Polia inferior*, Guen., and *Prodena litura*, F. (5). These caterpillars cause great losses to early planted maize if the land is dry and are at the same time very troublesome to other crops. They are particularly fond of "Pigweed" (*Amaranthus* spp.) and clean cultivation for some time before planting goes far towards defeating them. Wilkinson urges that where cutworm is a danger, the maize should be planted within three weeks of the advent of the long rains and losses from this cause will then be minimised. Early planting is to be recommended for other reasons, as has

already been indicated. Wilkinson also states that he has had considerable success in Kenya with a poison bait composed of one lb. of Paris green to 60 lb. of bran used dry at the rate of 20 lb. to the acre. Small dusty ground beetles, *Gonocephalum simplex*, F., another pest in young maize, is also attracted and killed by this bait. Ear-worm, *Chloridea obsoleta*, is on occasions a serious pest though it sometimes may be seen to attack badly one or two fields in a district. Unfortunately it causes additional damage by facilitating the entry of ear-rottingf ungi into the cobs which through its attacks are exposed at the tip.

Stalk-Borers (*Sesamia calamistis*, Hmpsn. and *Busseola fusca*, Fuller) are chiefly a danger in the Nakuru area and here complete success has, on occasion, attended the enforcement of "Stalk-Borer Rules" by which planting is prohibited in that district after a certain date. Destruction of all maize roots, stalks and shelled cores is also enforced, as these may serve as refuges for the pupae of the parent moths of the stalk-borers. "Volunteer" maize must also be up-rooted. But for the application of these Rules it is certain that maize-growing would soon be impossible in the Nakuru area.

For some reason which has not yet been explained the Stalk-Borer is seen only to a very limited extent in the Trans Nzoia. Although this is not a common pest, there was in 1931 a sudden invasion of a species of Army Worm in the Kitale district of the Trans Nzoia and their ravages made it necessary to plough in a great many hundred acres of maize. This onslaught ceased as suddenly as it had started.

Weevils.—Several species of weevils, the most important of which is *Calandra oryzae*, L. do great damage to maize in Kenya especially in the Trans Nzoia where the presence of a considerable amount of damp maize, as in the 1930 season, sometimes encourages the spread of weevils to an alarming degree. Since the temperature is high throughout the year, as in other tropical countries, the climatic conditions are very favourable for the continual multiplication of these pests. It is usually possible only to fumigate maize intended for seed or for labourers' food, and control can only be effected by the use of temporary cribs and by removing all maize from the farm as early as possible, subsequently thoroughly cleaning out all permanent cribs, and thus leaving no places of refuge for the weevils. The persistent way in which weevils spread and perpetuate unless most rigorous precautions are taken was illustrated to the author on finding, in August, weevils crawling on the tassels of maize in a breeding plot situated some hundred yards from a crib in which the previous year's maize had been removed a month or so earlier.

Locusts.—Kenya is subject to periodic invasions of locusts bred in desert or swamp land lying farther to the North or the West in Africa. These insects are very voracious both after hatching, during the "hopper" stage, and during the swarming and flying stages.

In 1928 and 1929, the Desert Locust (*Schistocerca gregaria*), was the most abundant, and some £55,000 were spent by the Government in 1929 in combatting this pest. In 1931 another species, the Migratory Locust (*Locusta Migratorioides*), made its appearance despite strenuous efforts to destroy the swarms in the "hopper" stage, the survivors, together with immigrant swarms from Uganda and Tanganyika, have done damage which, at the time of writing, is estimated by the Department of Agriculture to represent at least 20 per cent. of the Kenya maize crop. Some hope, however, is held for the future by the theory that the swarming period for any one species of locust occurs only once in eleven years.

White Ants.—These may cause a certain amount of damage, chiefly through soiling cobs on fallen stalks by boring.

(*b*)—*Fungous Diseases.*—Stalk and Root rots of maize, amongst which *Fusarium moniliforme* has been identified, are factors of supreme importance in the maize industry, especially on poor, acid, sandy soils, and it is impossible to compute the losses which are brought about by their incidence though these must be relatively very large. Amongst ear-rotting organisms Pink Ear Rot, *Gibberella saubinetii* (Mont.) Sacc., is the chief fungous concerned. It is also largely responsible for early losses of stand through rotting of seed in the ground and, under certain conditions, it produces a "seedling blight". In the Nakuru district, Head Smut, *Sorosporium reilianum* (Kuhn) McAlpine, may sometimes give up to 30 per cent. or more of infected plants in any field so that all infected plants must be cut out, removed in double sacks, and destroyed by fire. In the Trans Nzoia, this disease is of rare occurrence. On the other hand White Blight, *Helminthosporium turcicum* Pass., is much more severe in its occurrence in the Trans Nzoia, where it is probably associated with an excess of aluminium and iron salts in the acid soils and a corresponding lack of lime, phosphates, and potash salts. Selection of resistant plants for seed parents is recommended. In general, for the pathogenes of *Fusarium* type, seed-selection and disinfection, soil improvement and field sanitation, are suggested as means of control. (1), (4).

(*c*)—*Animal pests.*—A list of the animals which cause damage on some maize fields reads rather like a Zoological Garden's catalogue. Elephants and giraffes may be "pests" on some individual farms, but the smaller animals are responsible for greater losses. Porcupines have the habit of gnawing maize stalks at their bases and, the stalks being "felled", of feeding on the cobs thus brought within their reach, more cobs being spoiled than eaten. Wild pigs may cause some harm, and a series of predatory raids by a tribe of baboons, carrying away cobs by the armful, may soon reduce the yield of a "shamba". Lastly, it is not unknown for natives to misappropriate a settler's maize.

Economics of Maize Farming in Kenya.

The acreage usually put under maize by individual farmers in Kenya is large, varying from 200 acres to 3,000 acres. Under the present system of "one crop" farming, an economic unit is about 800 acres.

The average price per quarter for Kenya maize in London during the years 1923 to 1929 inclusive was Sh. 36-1*d*. which is over Sh. 10*s*. per bag of 200 lb. *f.o.r.* main line in Kenya, or about Sh. 8/50 *c*. per 200 lb. on the farm, that is, exclusive of bag and transport to rail head. The price in London had dropped to Sh. 24-7*d*. per quarter in 1930 and to Sh. 19-10*d*. early in 1931. The latter price is equivalent to about Sh. 4/50*c*. per bag *f.o.r.* main line Kenya, less Sh. 1/50*c*. for bags and transport. As will be seen from the above figures, there has been a sudden drop in maize prices. In order to save the industry the Government of the Colony raised the price to Sh. 6*s*. per bag *f.o.r.* (equivalent to Sh. 25*s*. per quarter in London) by means of a subsidy for the 1930 crop. No promise has been given, however, of a subsidy for the 1931 crop.

Costs of maize growing in Kenya vary considerably from farm to farm. A bulletin recently published by the Kenya Department of Agriculture (4) states that the cost per acre of maize-growing varies in Kenya from Sh. 35*s*. to Sh. 67/50*c*. per acre including bags and transport. The conclusion is reached that, for successful maize farming, yields of at least 13 bags per acre are essential when maize prices remain no higher than Sh. 25*s*. per quarter.

As has previously been stated, the average annual yield per acre during the ten years period 1920-21 to 1929-30 was 6.56 bags per acre, the yield for 1929-30 being 7.94 bags. The lowness of the average yield (6.56 bags per acre), is due to the fact that there is a considerable acreage of poor land under maize in the Colony. Much of this land must inevitably go out of cultivation during times of depression. Again, much of the farming is of low standard. Indeed there are many reasons (4) why the average yields have not been as high as they should have been, considering the excellence of the climate and the suitability of the soil. Nevertheless the average yield of maize per acre in Kenya compares very favourably with that for South Africa, which is given as five bags per morgen (2.37 bags per acre) (6). The average annual yield per acre for the United States of America., calculated over the period 1920-28, is 28.19 bushels (8.46 bags). The more general employment of intensive and improved farming methods in Kenya, involving the keeping of stock and the practice of green manuring—both of which are coming into general practice—must inevitably result in increased average yields per acre.

For several years the Kenya maize farming industry suffered the disadvantage of a "boom" by which haphazard methods of farming did not meet with a just retribution. The serious fall in prices during the depression of the last year or so has brought home to maize growers the necessity for improving their mode of farming, and for reducing costs per bag, especially by increasing yields per acre. A minimum return of 13 bags per acre has been mentioned above as usually requisite for successful maize farming so long as prices remain near the present level. While this yield is considerably above the average yields which have been obtained during the last few years when prices were more favourable, it is certain that great improvements can be effected, and that the standard can be attained over large areas in the Colony.

In 1930 at the Plant Breeding Station, Njoro, yields of 21 to over 24 bags per acre of marketable maize were obtained on small breeding plots which had received six to eight tons of boma manure and 100 lb. to the acre of superphosphate, even in spite of the facts that this station is situated at an altitude of over 7,100 feet and that the temperature during the growing season falls as low as 41°F. and rises no higher than 79°F. Yields of over 20 bags per acre on nine-years-old maize land have been realized in some parts of the Trans Nzoia, whilst spacing experiments conducted by the Department of Agriculture in 1930 on the Kitale Plains, gave yields varying between 17 and 27 bags per acre on nine-years-old maize land, that had been neither manured nor intensively cultivated.

On the rich forest soil of the foot-hills of Mount Elgon, yields of 25 bags per acre can be obtained without difficulty, and yields of 35 bags (117 bushels) and over have been recorded. In the Nakuru District, yields of 25 and 30 bags per acre have been obtained where the standard of farming has been high.

Maize grading and conditioning.

Kenya maize owes a great deal for its pre-eminence in the London market, even when the market is poor, to the careful grading and conditioning to which all export maize is subjected at Mombasa before it is allowed to leave the country with an Export Certificate. The highest commercial grade, 'K.2', must be below 12½ per cent. of moisture, and must contain less than eight per cent. of discoloured grains. A Conditioning Plant at the Coast, which is also run by the Department of Agriculture, treats all weevilly or damp maize at a charge of 80 cents per bag.

Maize breeding and Experimental Work.

The Plant Breeding Services, under the direction of G. J. L. Burton, Senior Plant Breeder, are at present concentrating on producing lines of inbred maize from which may be obtained, by subsequent crosses, varieties which are resistant to White Blight, and the various Fusarium rots of root, stalk and ear. This work is being conducted by the Agricultural Officer stationed in the Trans Nzoia for the benefit of the two main maize areas; at the Plant Breeding Station, Njoro, and at the Scott Agricultural Laboratories, Nairobi, though at the two latter stations wheat is the crop chiefly studied.

The Officers of the Plant Breeding Services, are also concerned in the prosecution of investigations on the spacing of maize. This problem is

being approached by means of statistical spacing experiments and by field censuses, based on the method devised by Professor Engledow at Cambridge University.

Other experimental work includes investigations on practical means for securing perfect stands by the employment of various methods of planting and of thinning, upon the frequency in the rotation with which a green manure crop must economically be grown in various districts, on the inter-planting of maize with green manure crops, on the effect of seed disinfectants, and on the effects of applications of varying amounts and forms of phosphates and lime.

In co-operation with the Royal Agricultural and Horticultural Society of Kenya, the same Services are conducting a Maize Seed Competition which includes replicated yield trial plots of seed from the various entries. This Competition, as a step towards improving seed maize, marks a definite break from the traditions of the old "Show Cob" competitions which had no scientific or logical basis. The competition should do much to stimulate the production and sale of better seed maize amongst the farmers of the Colony with a reflected improvement in maize yields.

The future of Maize Growing in Kenya Colony.

Any remarks by the writer on this topic must be made with reservation since Kenya is but a small unit in the aggregate of producers in World Agriculture, and its fortunes must to a large extent rise or wane together with international prosperity or decline. It is his firm belief, however, that the old days of maize "ranching" must pass. In former years, with the original fertility of the soil unimpaired, only small yields of maize were needed, at the high prices then ruling, to cover costs of production, and extensive methods were therefore feasible. This situation no longer holds good. At the same time it would seem that Kenya maize, when grown only on suitable soil and in its proper place in a mixed farming rotation, will be able to retain its "niche" in the world's maize market—even at low prices. This can obtain, however, only if full advantage is taken of the Plant Breeding work conducted during the last few years by the Department of Agriculture, and of experimental work designed to improve the practice of maize-growing in Kenya.

Although the dangers of disease and of insect pests are now being properly realised by the farmer, there are aspects of maize growing in the future which must be given greater thought if the industry is to continue, or indeed if any cultivation is to succeed. One of these is that of the subject of soil erosion. Unless erosion is promptly met by adequate draining, employment of green manures and cover crops, afforestation, and use of "wash stops", it is inevitable that large portions of the settled areas which are now fertile will become barren wastes. The peril is one which South Africa is now combating at considerable cost, because it was realised too late. In many districts of South Africa the stable door is now being locked when "the horse", in the shape of the invaluable few top inches of soil, has already been stolen by the thieving runnels of the rainy season—despite a relatively low rainfall.

Not entirely dissociated from depletion of soil resources by erosion, loss of humus and mineral salts results from continual cultivation without returning to the soil organic and artificial manures. Gracie has shown (1) how "exchangeable Calcium" and "total Nitrogen" in field soils are reduced by years of cultivation, and how "exchangeable Calcium" in soil bears a close quantitative relationship to the amount of organic matter present.

Since the maize kernel only contains .01 per cent. of calcium, the loss of lime per acre due to the removal of the crop, should be comparatively small if there were not additional losses through leaching.

The lime content of the less acid soils may be preserved by judicious organic manuring, and further losses may be diminished, even on deteriorated soils, by growing green manure crops where possible. Nevertheless the lime-humus complex forms a vicious circle, and excessively acid soils even fail to retain organic manures which are given to them. Where the subsoil is excessively acid there is no means of restoring fertility permanently without the use of lime; and farmers of acid sandy soils in some parts of the country are faced with the problem of liming their land at a great cost during the current period of low prices of agricultural produce.

The difficulties at present appear to be unsurmountable: but the eventual solution may lie in increasing stock and exporting greater quantities of dairy produce. In this way, soil fertility may be restored by degrading some of the maize lands to temporary pastures, while the sale of higher-priced products (assuming that maize never regains its former high value), may permit of a gradual and progressive liming of the land. Fortunately there are many parts of the country where now no serious soil problem is presented but farmers in possession of such land must give attention to the warning that sooner or later their land will become worse rather than better, and that they must take the necessary steps to preserve its fertility before the same fate overtakes them as that which has overtaken their brethren in other parts of this country and of the world.

REFERENCES.

(1) Gracie (D. S.): "A Preliminary Survey of Some of the Soils in Kenya." Kenya Department of Agriculture, *Bull.* 1, 1930.
(2) Maher (C.): "Ear Rots and Root Rots of Maize in Kenya and some Suggestions for their Control." Kenya Department of Agriculture, *Bull.* 5, 1931.
(3) Burton (G. J. L.): "Advice to Maize Growers." Kenya Department of Agriculture, *Bull.* 2, 1930.
(4) Burton (G. J. L.) and Maher (C.): "Improvement of Maize Yields in Kenya Colony." Kenya Department of Agriculture, *Bull.* 6, 1931.
(5) Wilkinson (H.): "The Control of the Cutworm". Kenya Department of Agriculture, *Bull.* 12, 1931.
(6) Handbook for Farmers in South Africa. Department of Agriculture, Pretoria, 1929.

FORESTRY AND AGRICULTURE.

The development of a forest policy in the tropics.

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Introduction.

The most frequent question which the writer has been asked during his service as a Forest Officer has been :—"What exactly does a Forest Officer do"? Apart from such apparently simple pastimes as watching trees grow, cutting them down and planting them again, the activities of a Forest Officer appear to be wrapt in mystery. Indeed, he is often darkly suspected of retiring to his forest bungalow for a more or less prolonged rest cure! One of the reasons for this lies undoubtedly in the lack of educational forestry propaganda; and it is because of this widespread lack of knowledge of what Forestry means and even of the full value of the forests as assets to the community that the writer has endeavoured to condense into a short article some of the aspects of Forestry involved in the development of a scientific forest policy in the tropics. It will be readily appreciated that it is only possible in such an article to touch the fringe of some of the varied aspects of a science in which a preliminary training of four years is now demanded.

The agriculturist may, not unnaturally, ask "What has Forestry to do with me anyway?" It is suggested that it has a very great deal to do with him. Agriculture and Forestry are linked together from the earliest stages in the development of a country when the formulation of a land policy is under consideration. Further, the agricultural community has the right to expect certain benefits from its forests: it should, therefore, have some idea of what those benefits are and how they are to be obtained and maintained. As a minor point, the Agricultural Officer is well advised, in some countries at any rate, to keep in touch with the Forest Officer, since the latter often has the best shooting up his sleeve and a forest bungalow for the rest of the weary hunter.

A Forest Policy.

Very briefly summarised a typical forest policy for a country might read as follows :—"So to manage the forests of the country that the greatest benefit may be obtained for the community both from the indirect utility of forest growth and from the utilisation of forest produce on the basis of a sustained yield." Some understanding of what such a policy involves should become clear as the various steps necessary to put it into effect are outlined.

Allocation of Land to Agriculture and Forestry.

Forestry has been aptly termed the handmaiden of Agriculture, and a consensus of expert opinion has laid down that the agricultural community, if it is to have an efficient handmaiden, should retain some 25 to 30 per cent. of its total land area under forest. Unfortunately, in the tropics, the allocation of land to agriculture is frequently carried out in a more or less haphazard fashion, accompanied by shifting cultivation with its attendant evils, and resulting in lands endeavouring to grow agricultural crops for which they are totally unsuited, the frequent reversion of such lands sooner or later to worthless "bush"—a fruitful source of fires—and sometimes in reservation of forest land below the minimum margin of safety. Ideally the allocation of land to Agriculture and Forestry should be based (*a*) on the dictates indicated by the data obtained from a preliminary ecological reconnaissance survey and (*b*) on a full consideration of the utility of forest growth to the community. Such a land policy demands the co-operation of agriculturist and forester.

(*a*) *The preliminary ecological reconnaissance survey.* This should have as its main object the division of the country into its unit regions so that the areas best suited to Agriculture and Forestry can be classified; it may be effected by level linear surveys running at right angles to the main topographical features or better still by aerial photography backed by adequate ground investigation for the proper interpretation of the photographs. The further final sub-division of the country into sites, *i.e.*, areas separable owing to a peculiar combination of some or all of the factors of climate, topography, geology, soil, vegetation and human usage, will form the work of later surveys.

(*b*) *Consideration of the utility of forests.*

Forests present two kinds of utility—direct and indirect. Their direct utility obviously lies in their ability to supply the community with timber, fuel, and a variety of minor forest products such as oils, gums, cork, tanning and thatching materials and so on.

Their indirect utility, which is of particular importance to the agriculturist, may briefly be summarised as follows :—

(1) *Temperature.*—Forests tend to modify extremes of temperature, since the temperature in and around forests by day is lower and by night higher than in open country, while the mean annual temperature is slightly lower; this effect, owing to constant interchange of air, is communicated to the surrounding country.

(2) *Humidity.*—Mainly owing to temperature the relative humidity of forest air is higher than that of air in the open country; evaporation from the soil, therefore, tends to be less and humidity is thus preserved by forests.

(3) *Mechanical effects.*—Forests on hills regulate stream flow and prevent the erosion, landslips, and floods which are the inevitable result of the deforestation of steep hillsides. They act as windbreaks, lessening the mechanical damage done by wind and decreasing the activity of the wind as a soil-drying agent. The roots of the trees bind the soil, and can control shifting sands.

(4) *Fauna.*—Forests shelter insectivorous birds which are of value to the agriculturist and preserve the natural fauna of the country.

(5) *Scenery*.—Forests maintain the artistic beauty of the country side.

In the allocation of land to Forestry both kinds of utility must receive full consideration: the same forest may of course present both direct and indirect utility. Forests reserved for indirect utility should as far as possible be located on areas unsuitable for Agriculture—here again co-operation and consultation between agriculturist and forester is indicated.

Demarcation and Legislation.

The next step is to draw up a programme providing for the continuous survey and demarcation of the areas reserved for Forestry, and the maintenance of their boundary lines; to legislate for their protection and for the collection of forest produce, and to organise a staff for their supervision.

Stocktaking.

Before any further progress can be made on a safe basis, it is now necessary to take stock in the forests. By stocktaking the modern forester understands, or should understand, the combination of an ecological survey with a statistical assessment of the forest resources. Unfortunately, until very recent years stocktaking has often been understood as the statistical assessment of the forest resources only. It is safe to say, however, that it is the neglect of the ecological aspect which has been responsible not only for the frequent lack of a fundamental land policy, but also for many of the more serious blunders made in the practice of Forestry. Appreciation was given to some of the ecological factors, but not to the proper combination of all the factors which go to make up the ecological aspect in its true and broadest sense.

Before undertaking this work, careful consideration must be given to the amount of detail into which it is proposed to enter. The forester wants as rapidly as possible certain data from the statistical survey, such as the distribution of species and crops, their classification into age classes and their yield capacities. At this stage in the life of the Forest Department, funds, staff and time may, however, be limited. If, therefore, he allows his ecological enthusiasm to run away with him and undertakes too detailed an investigation he may postpone over long the introduction of that part of his scientific forest management which is based on the statistical assessment. Further, it is almost impossible for a single individual, certainly for a general Forest Officer, to possess all the knowledge required for a detailed scientific examination on the ecological side: co-operation with specialists is required and these may not be available. On the other hand, if his survey includes insufficient detail, much of the value of the work done will be lost, not only with regard to the original survey but to subsequent re-enumerations for comparison. He must therefore cut his coat according to his cloth and work out the programme of investigation accordingly.

The investigation might proceed somewhat on the following lines:—

The preliminary reconnaissance survey has separated up the country into its unit regions. A more detailed survey must be undertaken over the areas allocated to Forestry and this can again be done by adopting the principle of sampling and running line transects at right angles to the main topographical features. The lines should be sufficiently close to each other to admit of at least a one per cent. enumeration. In this survey not only are the species, number and dimensions of the trees taken into account but also regeneration in its various stages, the nature of the ground flora and lower story of the forest and the physiographic and edaphic conditions. At the same time local climatic conditions should be studied and a systematic collection of herbarium material made, whilst the silvicultural characteristics of individual trees of each species should be observed and noted as far as is possible.

It is only when the data from this survey have been collected and analysed that the forester has obtained amongst other things:—

(*a*) From the ecological study:—

A correlation between the different forest types and their habitat conditions, and some understanding of the vegetative and regeneration processes—knowledge essential to the success of future silvicultural operations.

(*b*) From the statistical enumeration:—

A reasonably accurate estimate of the quantity, age classes and distribution of the various species—knowledge essential to the introduction of forest management and the regulation of the yield.

In other words, until after the stocktaking neither forest management nor silviculture can rest on a sound and scientific basis.

Forest Management.

His stocktaking completed, the forester can now turn with some confidence to the introduction of scientific forest management into his forests. Forest management is based on two main fundamental principles:—

(1) The principle of living on the interest and conserving the capital.

(2) The principle of a sustained and equalised yield.

Troup defines the normal forest as one which contains a complete succession of age classes from the youngest to the oldest and in which all the age classes are represented in the correct proportion, density and distribution, so that as each class becomes ripe for felling it may be cut in its proper turn and regenerated, and the out-turn will be equal each year or period of years so long as the normal state of the forest is maintained.

Such a forest is the ideal forest and it fulfils both of the above-mentioned basic principles, since each year the oldest age class can be cut,

and this age class represents the total interest or increment of the forest (principle (1)) and contains the same volume year after year (principle (2)).

In practice, however, the normal forest can hardly be said to exist—it is an ideal to be striven for: and with this ideal in his mind the forester turns his attention to managing his tropical forests. From the statistical survey he finds at once that they are very far away from normality. In the unexploited mixed forests the bulk of the crop consists of species which are not marketable, whilst the marketable species are few and far between with their age classes far from being in the correct proportion, density and distribution. Also, in the exploited mixed forests all the marketable trees may be cut out and only the unmarketable remain. Tropical mixed rain forests, it should be noted, may contain some 40 or more different species to the acre, with consequent expensive extraction of the marketable trees.

A form of management, however, following on the two main principles mentioned above can still be introduced, for a yield control, based on the figures obtained from the statistical enumeration, can be prescribed for such marketable species as exist, which will ensure an equalised annual yield consisting only of the increment put on by those marketable species. It was by this means that Brandis saved the teak forests of Burma from practical extinction: in a similar way the yield from the diminished supplies of cedar in the Trinidad forests is being controlled.

The actual constitution of the crop in such forests is, however, obviously unsatisfactory. The bulk of the crop being unsaleable the yield per acre is necessarily small and the question of the improvement of the crop immediately forces itself on the attention.

Silvicultural operations.—Silvicultural operations aim at improving the growing stock of the forest and thus at increasing the yield. This may be done in two ways:—

(1) By improvement fellings, in which may be included any operation which aims at artificially assisting the existing marketable species and the natural regeneration therefrom against the non-marketable. Here a sound knowledge both of the ecological factors and of the silvicultural characteristics of the various species is essential, or the action taken may hinder rather than help the desired species.

(2) By replacing the existing forest with an artificially formed crop of valuable species only.

The first method covers large areas rapidly, but its results can only be estimated by successive re-enumerations and the progress towards normality is slow. The second method aims at bringing the forest close to normality in one rotation. The relative expenditures involved are difficult to assess, since improvement fellings are carried out at a relatively low cost but over a prolonged period, whilst the alternative method requires a relatively high expenditure, but for a short period only.

Silvicultural Systems.—Normally, silvicultural work is carried out under some silvicultural system. Troup defines a silvicultural system as "the process by which the crops constituting a forest are tended, removed, and replaced by new crops, resulting in the production of woods of a distinctive form. Such a system embodies three main ideas (1) the method of regeneration of the individual crops constituting the forest (2) the form of crop produced and (3) the orderly arrangement of the crop over the forest as a whole with special reference to silvicultural and protective considerations and the economical utilisation of the produce."

The practical application of silvicultural systems is closely connected with the requirements of forest management and whatever silvicultural system is employed the object is the final creation of as nearly a *normal* forest as is possible.

Silviculture and Silvicultural Characteristics.

Now a silvicultural system presupposes a knowledge of the principles of silviculture and these in turn are based on the silvicultural characteristics or requirements of trees. In the tropics, owing to the infancy of tropical forestry, the Forest Officer is usually faced with a complete lack of data as to these requirements of the species which he desires to grow. Some knowledge has been obtained from the stocktaking, but this must be supplemented by silvicultural research, which aims at obtaining the following information with regard to each individual species: the locality and soil conditions to which it is best suited; the light requirements essential to its optimum growth; its reproductive powers; its suitability to be grown pure, or mixed with other species, and if so with what species; the shape and development of its root system and crown; its susceptibility to external injuries such as wind, insects and disease; its rate of growth; its age at maturity; its utility. Once a complete knowledge of these silvicultural characteristics has been obtained, coupled with a thorough understanding of the reactions of the species to the factors of the locality, it should be possible to grow any species—subject, of course, to abnormal external factors.

Working Plans.

An endeavour has been made to explain that the requirements of forest management, the application of silvicultural systems to crops, the principles of silviculture, the silvicultural characteristics of individual species and applied ecology are all closely interdependent and interrelated. Their satisfactory mutual arrangement and application to a given forest area is usually a somewhat involved and complicated operation. Because of this and because continuity

of policy and practice is essential in such a long range crop, the management of a forest area is drawn up in a document which we call a Working Plan.

The average Working Plan is prepared for a period of ten years, after which it undergoes revision. It is divided into two parts, the first containing a description of the facts as they exist, together with a collection of all the data of value available, and the second containing comprehensive prescriptions as to the method of management to be followed in the future, as to the yield to be cut and as to the control and execution of the plan.

The prescriptions as to the method of management to be followed lay down, amongst other things, the species to be grown, the silvicultural system or systems to be employed, the rotation, and the general lines of treatment in respect of methods of formation, regeneration and subsequent tending and thinnings. The modern tendency is for the silvicultural prescriptions to become more and more elastic and to leave more latitude to the officer in charge of the regeneration operations. The prescriptions for a Working Plan once sanctioned must not be violated, except under very special circumstances; continuity is thus assured and the forest is not at the mercy of the whims of the individual officer temporarily in charge.

Forest Finance.

A brief reference may be made here to forest finance. Normally it is just as important that forest areas, other than those which are purely protective, should be paying concerns as it is for agricultural areas. Money, in the case of forestry is usually considered as being invested at compound interest over a period of years: theoretical calculations as to the profitableness or otherwise of the undertaking are apt to be upset by the fluctuating prices of timber. Nevertheless the forester must see to it that his initial costs of formation and subsequent tending are not such as to preclude a probable rate of interest on the capital invested which is at least on a par with that obtainable from money invested elsewhere with equal security—assuming of course that a reasonable return from the money invested is one of the objects of management. In some instances trees may be grown on a rotation far beyond the limit of profit in order that they may produce timber of a quality required for some purpose in connection with the staple industry of that particular district.

General Research.

Concurrently with the prosecution of the steps outlined above there is urgent need for research in numerous other directions, such as:—the technical properties of the timbers of the country, their seasoning and utilisation; the collection of statistics as to the rate of growth and the outturn of plantations, natural crops and individual trees; thinning technique in plantations; minor forest products; diseases and pests; botanical research and so on.

Conclusion.

Despite a fuller appreciation by many in recent years of the importance and implications of the science of ecology, there is still a lack of that co-operation between agriculturist and forester which such an appreciation dictates. Indeed, the forester is still sometimes regarded in the light of a land grabber whose aim is the subordination of the interests of agriculture to forestry, instead of as a fellow worker with the agriculturist.

It is felt that a step in the desired direction might well be a fuller understanding by the agriculturist not only of the benefit of the forests to him, but also of the methods which are adopted by the forester in an endeavour to obtain and maintain the maximum benefit possible, and the writer has endeavoured to indicate something of those methods. The agriculturist and the forester are both users of the soil; several of the sciences in agriculture and forestry run on similar or parallel lines. There is still a vast area of land within our Empire awaiting development, and it is urged that the fullest and best development can only be obtained by close co-operation and understanding between the trained agriculturist and forester.

TANGANYIKA BEESWAX.

The export of Beeswax from Tanganyika Territory for the period January to June in the year 1931, reached a total of 4,075 cwts., valued at £18,012.

During the corresponding periods of the two years previous, the export was:

1930 .. 1,079 cwts., valued at £ 6,939
1929 .. 3,651 cwts., valued at £26,628.

The total production for 1930 has already been exceeded by 302 cwts.

In these times of depressed production level, it is gratifying to be able to record one commodity whose output has increased to such an extent. The price is low—an average of about 90s. per cwt. as compared with 144s. in 1929—but the proportionate reduction is not so great as with other native products. The present season has been good for bees, and colonies have developed to a much greater extent than has been observed during the last four years. Swarming during the period December to July was considerable in many parts of the Territory, and was rather a nuisance in township areas.

The greatest increase in production has been in the western part of the Territory where the better quality waxroriginates, and where the Department of Agriculture is mainly responsible for the improvement of methods of wax preparation and bee keeping generally. Honey is plentiful and in good demand for local consumption. At present prices it is a serious competitor of the locally produced coarse brown cane sugar, "gur".—(*By Courtesy of the Assistant Entomologist, Entomological Laboratory, Department of Agriculture, Morogoro, Tanganyika Territory.*)

PANAMA DISEASE.

The use of Chemicals for killing Bananas in the treatment of Panama Disease.

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PANAMA Disease of bananas was first recognised in Jamaica in 1912, during which year a few isolated cases were found. In order to limit the spread of the disease, immediate action was taken by the Government to make it compulsory by Law that all outbreaks of the disease should be immediately reported and Legislation was also enacted making treatment of the disease compulsory in accordance with regulations ordered by the Governor.

The method of treatment originally adopted consisted in digging up the diseased plant, followed by its immediate and complete destruction by fire. In addition, all the healthy plants within a considerable radius of the diseased plant had to be dug up, chopped into small pieces, and heavily treated with lime. The area so treated was then fenced in, and maintained in a state of quarantine.

This method of treatment with slight modifications and with a smaller quarantined area has been continued ever since. The destruction of all the banana material which is heavily infected with *Fusarium cubense* together with the quarantining of the area in which the soil is potentially infected with the fungus, has considerably checked the spread of the disease in Jamaica.

With the increase of the number of cases of the disease in recent years, it has been more and more difficult to carry out this treatment as efficiently as is desirable. In the first place it has been appreciated that the moving of infected soil in digging out the diseased plants, more especially on river banks and steep slopes where washing is liable to take place, is far from desirable. Secondly, the banana is a most difficult plant to kill completely, and the necessity for large quantities of fuel to destroy a whole banana plant is not only expensive in many cases, but in some areas which are under heavy cultivation, the quantity of fuel is difficult to obtain. Furthermore, in districts of very heavy rainfall, and where the soil is a heavy clay, there are seasons of the year when satisfactory digging up of the infected plant and the surrounding healthy plants is exceedingly difficult, and its further destruction by fire during continuous rains is almost impossible. As a result of this the secondary growth in quarantined areas has been very large, often calling for three or four subsequent pruning treatments.

It has been realized for a number of years that if a satisfactory chemical could be found which would kill the banana *in situ* without the necessity for digging up the roots and thus disturbing the infected soil, it would materially facilitate the treatment of the disease. In consequence a wide range of chemicals were used in experiments carried out by Hansford (1), in 1923. He stated :—

"From time to time various people have considered that the disturbing of the soil around the plant necessitated by the digging, results in a spread of the disease from the original site of infection. With the idea of overcoming this objection, the Department experimented with other methods suggested. A number of poisonous chemicals were tried, but none was found to work at all satisfactorily, and none could be relied on to kill the underground parts of the banana. Among the chemicals used in these experiments were the following which were administered in large doses to the soil immediately around the root of the banana.

Arsenite of Soda.	Corrosive Sublimate.
Arsenate of Lime.	Sulphuric Acid.
Turpentine	Tar.
Carbon Bisulphide.	Copper Sulphate.
Rock Salt.	Benzol.

Another plant was treated by making a hole in the soil under the plant and pouring in Gasolene and igniting it. As stated above, none of these treatments was found efficient, and none could be relied on for general use by our Inspectors in treating the disease. In fact, it would appear that the only way of killing a banana plant is to dig it up completely."

Further experiments showed that with the exception of arsenicals, none of these chemicals proved a success. Apart from its cost, Sodium Arsenite is a most undesirable chemical to use for such a purpose. Furthermore if applied in sufficient quantity to kill the banana roots it leaves a fairly permanent toxicity in the soil resulting in inhibition of future plant growth.

Experimental Work.—At the request of the Director of Agriculture, Mr. H. H. Cousins, experiments were continued in 1930. An examination of Hansford's results showed that there was no advantage to be gained by repeating them. Other chemicals were therefore used in the small preliminary tests.

Caustic Soda both in solution and the solid form was applied at rates as high as two lb. per plant without any success either upon standing trees or those cut back to soil level.

In the second experiment, *Kerosene* was used at the rate of two gallons per plant and this proved entirely successful. This quantity, however, was too large and expensive for economic application. Furthermore the experiments were carried out on a light gravel soil which was only sparingly irrigated. The experiment, however, gave the indication to a line of work which has ultimately proved most successful and which will effectively reduce the cost of treatment which has to be faced annually by the Planters and the Government of Jamaica.

The preliminary experiments were followed by field trials with smaller applications of Kerosene per plant and were conducted at several places

to obtain maximum soil variation, from heavy soapy clay with high daily rainfalls to medium loams with moderate rainfalls. The quantity of Kerosene used varied from two gallons to three pints. In every case successful killing was effected when the banana plant had been cut back to a few inches of soil level before treatment.

Smaller quantities of Kerosene were then used under similar conditions of experiment, the quantity varying from one pint on small plant bananas to three pints on fairly large ratoons.

* These experiments resulted in practically 100 per cent. killing of the plants treated. Where death of the plant was not complete, the secondary growth was very small, not more than one small root per plant and which could be readily removed by hand.

While these experiments were quite satisfactory, it was appreciated that even the heavier grades of Kerosene were too expensive for general application though they could be used in certain special areas where the conditions warranted it. The need for a cheaper chemical was apparent before the method could be given general application and in consequence all available types of mineral oils were subjected to test in varying quantities. These tests were practically a repetition of the experiments carried out with Kerosene.

Five types of mineral oils were used of the following types :—

	Average Specific Gravity at 60° F.	*Average Flash-Point (close test).*
Heavy Bunker Fuel Oils	0.969	Over 200°F
Diesel Oils (mostly blends)	0.9049	
Heavy Gas Oils	0.8839	177-187°F
Light Gas Oils and Delco Oils	0.8559	145°F
Kerosenes		Below 150°F

As a result of these experiments * it is shown that :

Bunker Fuel Oil. — (The residue of the "topping" process of refining) was quite useless for killing bananas, in fact the young shoots grew through the residue of the oil on the surface of the soil quite unharmed even when an application of two gallons per plant was made.

Heavy Diesel Oil.—(A blend of Fuel Oil and Gas Oils) was partially successful only and required an application of one to two gallons per root to give a reasonable killing of the bananas ; too expensive for general application.

Heavy Gas Oil.—(The fraction from the "topping" process of refining) proved equally successful as Kerosene, the application used varying from two to three pints according to the size of the banana plant and resulted in practically complete death of the plants. (Later experiments with other Gas Oils are mentioned in the text.)

Light Gas Oils, Delco Oil and *Kerosenes* of various types also proved successful when used in similar quantities to Heavy Gas Oil, but in view of their higher cost have not been recommended for general use.

Further field trials were made with Heavy Gas Oil (Spec. Grav. up to 0.8869 average Flashpoint 181°F.) which supported the first experiments and this oil has now been generally adopted by the Government as well as by planters for use in the treatment of Panama Disease.

It must be mentioned, however, that all Gas Oils do not have an equal toxic effect. Those produced in Trinidad where the crude oils are not subjected to "cracking" or field fractionation, but are treated by a method known as the "topping" process, have shown the maximum toxic properties. American Distillates which are the result of closer fractionation have not proved so effective although* they have shown definite toxic effects upon the banana.

In order to protect the planter from exploitation, Legislation has been enacted requiring that all oils to be used for this purpose must first be approved by the Director of Agriculture. Such approval carries with it an undertaking from the suppliers of the oil that a certain standard will be maintained in its composition.

The method has been in general use by the Government Inspectors of Plant Diseases for some five months, and has proved to effect almost complete killing of the bananas. The Plant Disease Inspectors have been allowed to use discrimination in the amount of oil applied per root according to its size, although an extra heavy dose is invariably applied to the root which is actually attacked by the disease. *Seventeen Inspectors working in areas representing all conditions of soil and rainfall, during nine weeks treated* 33,427 *banana trees, both diseased and healthy, with an average application of* 1.503 *pints of Gas Oil per plant or "matt".* These treatments have proved quite effective in killing out the bananas, although in a few cases adventitious suckers have had to be removed. The method has been used by a number of planters with equal success.

The standard method of treatment consists in cutting off the diseased and healthy trees a few inches above the soil. The dry trash and other material around the roots is carefully removed to give a free passage to the oil in reaching the underground parts of the plant. The oil is then applied to the root and the soil immediately surrounding it in such a way that very little is applied to the cut surface, the

* The full detailed results of each test in these experiments are not given in this paper as they were entirely successful and the results have been borne out on general field application of the final method described later in the text. Actually twenty experiments were made with an average of ten plants in each test.

* It has not been possible to determine which particular element in the composition of these oils is responsible for the toxic properties but it is probably attributable to the lower surface tension of certain constituents of these oils and the penetration into the soil which results therefrom.

majority being allowed to penetrate the soil immediately touching the outside of the plant. In this way the oil readily penetrates to the underground buds and kills the "eyes" which would otherwise rapidly start new growth. The aerial portions of the diseased plant are cut up and either burnt or treated by sprinkling with oil according to the material available. It is found that a small quantity of the Gas Oil rapidly rots banana material and within a week or so, it is largely decayed. At first it was thought that it would be necessary to apply fairly large quantities of oil to the cut surface lest growth should recommence from the heart of the shoots. Experiment has shown, however, that large applications to this part of the plant are quite unnecessary, and concentration of the application of the oil must be made around the outside of such shoots.

With the successful general application of this method of treatment it has been found possible to cope much more effectively with Panama Disease in spite of adverse weather conditions. In the past, treatment of the disease frequently has had to be delayed on account of heavy rains and wet soil conditions which considerably interfered with the digging up of roots and burning of diseased plants. With the oil treatment, these disadvantages no longer apply as treatment can be continued during the wettest weather. Not only has delay in treatment of disease been prevented but the cost of treatment has been generally materially decreased. The expense and loss of time in obtaining the amount of wood or other materials necessary for burning the whole of a banana plant has been largely eliminated while the amount of labour otherwise involved has been reduced to less than a half, and in some instances to less than a quarter.

By the kind permission of Hon. Percy Lindo, on whose estate, "Ballard's Valley", very careful costs have been kept, I am permitted to publish the costs of treatment of Panama Disease under the old method and the new Oil treatment. It will be noted that the total costs for labour under the new treatment are less for 535 cases treated by Gas Oil than for only 182 cases under the old method of digging out the plants while the total average cost of treatment per case on this estate has been reduced to two-fifths, from 5*s.* 1½*d.* to 2*s.* 1¼*d.* representing a large saving per annum. A considerable saving is also being effected in the cost to the Government in treating Panama Disease.

Ballard's Valley Estate 1930-1931.

Old method of Treatment by digging out and burning.

182 Cases.

		Cost. £ s. d.	*Cost per case.* d.
Labour	....	26 19 7	35.56
Fuel	....	22 15 0	30.00
Lime	....	4 11 0	6.00
Total 182 cases	....	54 5 7	71.56

Average Cost per case 5*s.* 11½*d.*

New Method of Treatment with Heavy Gas Oil.

535 Cases.

		Total cost. £ s. d.	*Cost per case.* d.
Labour	....	22 3 9	9.95
Gas Oil	....	20 18 0	9.36
Lime	....	13 6 0	6.00
Total 535 cases		56 7 9	25.31

Average Cost per case 2*s.* 1¼*d.*

Effect of Oil Treatment upon future Plant growth.

Before the method could be put into general practice, it was necessary to determine whether the oils which it was proposed to put into general use would have any effect upon future plant growth. Accordingly a number of the sites of the experiments were planted with a variety of crops, care being taken that the actual places where oil had been applied were planted. The following plants were used:—Grapefruit seedlings about nine months old, sweet potato cuttings and cabbage plants, and ultimately some 20 spots were replanted with bananas. These replantings were made from two to six months after the application of the oil and with one exception, a grapefruit plant in which the cause of death was doubtful, all grew quite healthy and the bananas are now fruiting normally.

The effect of Oil treatment upon the incidence of Panama Disease.

The object of the investigation was to produce a sure method of killing bananas without digging them up and it was not anticipated that any such method would have any direct influence upon the spread or incidence of the disease, although by preventing the washing of disturbed infected soil and active material from infected plants, it was anticipated that some indirect effect might result. The method has not been sufficiently long in general use to give any positive indication of its effects upon the spread of the disease, but apart from the indirect influence mentioned *the oil treatment is also saving a great deal of infection of newly opened lands.* It has been found in the past that the adventitious suckers growing in a quarantined area have an extraordinary fascination for the small settler, who appears to prefer obtaining his planting material from such dangerous areas. In consequence, new areas, often of virgin land, have been planted with suckers from such plots, in spite of advice to the contrary, resulting in the rapid appearance of Panama Disease and an early abandonment of the holdings. Oil treatment practically eliminates this method of disseminating the disease which has been one of the greatest problems facing the Government in mountain districts in the past.

It is possible that Gas Oil may have some small direct action upon the spread of Panama Disease. Experiments with naturally infected banana material have shown that the oil to a

limited extent inhibits the growth of *Fusarium cubense* and most definitely reduces the amount of spore formation, while its destructive effect upon the banana tissues materially reduces the period of maximum activity of the fungus. Whether this aspect of the oil treatment will have any direct bearing upon the spread of Panama Disease remains to be seen.

It has been found in the past that early treatment of the disease (as soon as the first symptoms show in the leaves) tends to reduce the rate of its spread in the long run, probably on account of the fact that at this stage the fungus has not penetrated a great distance into the corm and pseudo stem. In fact, in the areas of high rainfall observations have shown that in the majority of cases the actual area within the plant into which the fungus has penetrated when the very first leaf symptoms appear, does not normally extend as high as soil level in bananas which are very old ratoons and are in consequence not deeply rooted.

It would therefore appear, and it is being strongly recommended in Jamaica, that if treatment with the oil is carried out at this stage, the infected zone within the plant will be entirely treated with oil, while the aerial portions will be free from disease and consequently not agents of dissemination.

Other Applications.

The treatment of Panama Disease as practised in Jamaica is one of a number of Agricultural problems involving the necessity for the total destruction of growing plants. The eradication of *Ribes spp.* in connection with the control of White Pine Blister Rust (*Cronartium ribicola*) the eradication of Barberries in the control of *Puccinia graminis* and the destruction of the Blackberry weed in New Zealand are well known examples.

In a recent paper by H. R. Offord (2) it has been shown that several species of Ribes may be killed by three applications of Sodium Chlorate solution. From correspondence with Dr. Cunningham of New Zealand it is understood that this chemical has given good results with Blackberry eradication. It is possible that as Gas Oil has proved to be so successful in killing the banana, a most difficult subject to kill, with only one application, that it would be equally effective for other similar purposes especially in the United States and other countries in which oil is produced and is correspondingly cheaper than in Jamaica.

Sodium Chlorate has not yet been tested for killing bananas in Jamaica, but rough estimates of cost have shown that it would not appear to have any advantage over Gas Oil on the score of expense. It also has the disadvantage that it is inflammable and not too safe in the hands of native labourers, in a thickly populated country. It is, however, intended that this chemical should be put to test for killing bananas.

In conclusion, I wish to record my appreciation of the able assistance of Messrs. J. B. Sutherland and N. E. Thomson of the Jamaica Plant Disease Inspectorate in connection with the field trials in this investigation.

REFERENCES.

(1) Hansford, C. G. "Panama Disease in Jamaica". *Jamaica Microbiological Circular No.* 5, 1926.

(2) Offord, H. R. "The Chemical Eradication of Ribes." *U.S. Dept. Agric. Tech. Bull.* 240. 1931.

PARAGUTTA.

An excellent example of the importance of research in industry is the invention of "paragutta," a material with which the new telephone cable, provided to supplement the growing traffic between the United States and Cuba, is insulated. For the past seventy-five years, the standard materials for insulating deep-sea cables have been gutta-percha and balata. Paragutta is a mixture of about fifty per cent. gutta-percha and forty per cent. rubber, and ten per cent. hydrocarbon wax. Its mechanical qualities are fully equal to those of gutta-percha its electrical stability in water is the same, but, it has much better specific electrical properties. In the *Bell Laboratories Record*, May, 1931, a description of the new material is given by A. R. Kemp. It is pointed out how the mixture can be extruded on to the conductor in a continuous sheath of multiple layers free from mechanical defects. The insulated conductor has then only to be drawn through cold water, when it quickly sets into a firm covering sufficiently tough and flexible to resist rough handling in factory or cable ship. The specific conductance of paragutta is only one-thirtieth of that of ordinary cable gutta-percha and its dielectric constant is twenty per cent. smaller. It follows that if paragutta had been available to insulate the permalloy-loaded telegraph cable laid five years ago its speed would have been thirty per cent. greater. Its revenue-earning capacity would thus have been increased thirty per cent. This is of great importance from the commercial point of view. The expense of failure in a submarine cable is unusually great. Minute defects in its insulation can do far-reaching damage. Very prolonged and elaborate tests were therefore necessary before the cable users and manufacturers were convinced that it was suitable for practical use.—(*Nature*, Vol. 128, No. 3223.)

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GROS MICHEL AND PISANG EMBUN.

BY

E. E. CHEESMAN.

SOME discussion has been current during the last few years concerning the question whether the Pisang Embun (also variously spelt "Embon" and "Ambon") of Malaya and the Gros Michel or Jamaica banana of the West Indies are identical or merely similar.

Identity was first suggested by W. N. Sands in the *Malayan Agricultural Journal*, Vol. XIII, 1925, p. 272, in these words : "The writer believes that the Malayan Pisang Embun is the same as the Gros Michel banana of the West Indies. Although it has not yet been possible to compare the local and West Indian forms side by side, still from a knowledge of the bananas in both countries, he is of opinion that if they are not identical, they very closely resemble each other."

S. C. Harland, in his report on a tour in Malaya, stated in *Tropical Agriculture*, Vol. V, 1928, p. 55 : "I saw some good specimens and was able to confirm Mr. Sand's view that Pisang Embon is probably Gros Michel."

In *The Banana*, by P. K. Reynolds (Boston, 1927), we find on pp. 14 to 15 a citation of O. A. Reinking as believing that "*Pisang ambon* or *Pisang medji*" is identical with Gros Michel.

A dissenti nt is P. R. White, who in his *Studies on the Banana* (*Zeits. fur Zellforsch. u. mikr. Anat.*, Bd. 7, 1928, pp. 673 to 733), found the chromosome number of Embun to be 36 (somatic) but that of Gros Michel to be 32.

The question is an important one for fundamental studies of the banana complex, and steps were taken to settle it by the only adequate method. Suckers of Pisang Embun were collected in Malaya by F. N. Howes, and after quarantine at Kew were sent by the Kew authorities to the Imperial College of Tropical Agriculture in October, 1928. After three years of observation I am able to state with complete confidence that Embun and Gros Michel are indistinguishable, and so far as certainty can go in a matter of synonymy, are one and the same clone.

After preliminary observations on the stools raised from the introduced suckers, a row of three Embun was planted, alternating in the row with three Gros Michel. The six stools resulting were carefully watched at all stages of their growth, and bunches of the two "varieties," of approximately the same age, were handed to the Low Temperature Station for report on storage and ripening.

At no stage were the smallest differences discernible in plants, inflorescences, or fruit. One bunch of Embun was pollinated by a variety of *Musa zebrina*, and gave two seeds—which is quite consistent with the general run of results from Gros Michel. Finally, towards the end of the experiment, Panama Disease appeared in the row and conveniently attacked two adjacent stools, which of course comprised one Embun and one Gros Michel. The progress of the symptoms ran parallel in the two cases and proved the susceptibility to be substantially the same. From a diseased stool of Embun, *Fusarium cubense* E. F. Smith was isolated by Dr. C. W. Wardlaw.

To complete the evidence, I have counted the somatic chromosomes in our Malayan material and find neither 36 nor 32, but 33. This number I find also in Gros Michel from West Indian sources, and I can see no way in which the chromosome complements in the two cases differ.

It is worth noting that Sands (*loc. cit.*) mentions that the Malays grow another distinct variety of banana which is quite green when ripe and which they term Pisang Embun Lumut or Pisang Masak Hijau. This is sometimes incorrectly referred to as Pisang Embun. White, in his list, gives chromosome counts for Pisang Ambon Loemoet, Java, which is obviously the same name. Heyne, in *De Nuttige Planten van Nederlandsch Indie*, 1927, mentions a Pisang Ambon Poetih (also in White's list) and a Pisang Ambon Idjo. The latter name strongly suggests "Hijau."

Masak Hijau is in the Imperial College collection and under comparison with certain other types, such as the Giant Fig of the West Indies, but no definite conclusions have yet been reached. It is mentioned here as an illustration of the ambiguity which may arise from a loose use of the name "Embun" or its variants, and to emphasize that the present identification concerns only the true Pisang Embun of Malaya, with fruit that ripens yellow.

THE FLIGHT OF FLYING-FISH.

The habit from which they take their name makes flying-fish so conspicuous and invites observation so much that it is curious to find there is still difference of opinion as to whether they really fly or only use their pectorals as parachutes. In the *Scottish Naturalist* (p. 121), Mr. W. L. Calderwood gives some notes on these fish, as observed in calm weather in the Arabian Sea. His observations were made carefully with prism glasses, and led him to the conclusion that the pace, which was very uniform, was maintained by the use of the pectorals at short intervals. Although it could not be seen, at a long distance from the ship, whether these fins were vibrating or not, it seemed to him that a flight extending sometimes even to 150 yards, and performed at only about a foot above the surface could not have been kept up except by renewed impulses from the fins. This was exactly the impression formed by the writer of this note after repeated naked-eye study of these fish on a first voyage into the same part of the world. They were seen at times to vibrate their fins when clear of the water, as well as when touching it with the tail, as is generally admitted and very carefully described by Mr. Calderwood in the paper alluded to. The impression their flights left was that of the starting flutter and patter of the moorhen, continuing as the glide and whirr of the partridge, with the difference that in the fish the end of the first glide was generally also that of the flight.—(*Nature*, Vol. 128, No. 3223.)

CACAO SOILS.

Carbon/Nitrogen Ratios in Cacao Soils.

[*We reproduce below the following letter by Professor Hardy and G. Griffith which was published in "Nature", Vol. CXXIX, No.* 3247.]

By tabulating and comparing the results of a detailed laboratory examination of profile samples of cacao soils collected in January, 1930, in the Island of Tobago, British West Indies, one of us (G.G.) was able to demonstrate* a close correlation between the yielding capacity and the carbon/nitrogen ratio for the organic matter contained in the surface six-inch layer of soil. The mean ratio for "good" soils yielding more than eight bags (or 1,320 lb.) of fermented and dried cacao beans per 1,000 trees (pickets) is 8.3 (21 samples), and for "bad" soils yielding less than eight bags per 1,000, 6.8 (10 samples). Statistically, this correlation is highly significant ($t=4.5$), and the C/N ratio is not necessarily dependent on the total amount of organic matter present ($t=1.1$). Although a complete explanation of this relationship is not yet forthcoming, the result implies that the nature of the organic matter present, rather than its total amount, is the primary factor concerned in the productivity of cacao soils under the climatic, cultural, and soil conditions that obtain in Tobago.

Afterwards, similar comparisons of yields and C/N ratios for cacao soil—profile samples collected in Trinidad and in Grenada, B.W.I.—have been established. The following additional results have been demonstrated.

	Mean C/N Ratios (Top 6 in. Soil)	
	"Good" Cacao Soils. (Yield, more than 8 bags/1000).	"Bad" Cacao Soils. (Yield, less than 8 bags/1000).
Trinidad	7.0 (54 samples)	5.7 (46 samples)
Grenada	8.0 (23 samples)	6.5 (12 samples)
Tobago (for comparison)	8.3 (21 samples)	6.8 (10 samples)

Whilst these results substantiate the earlier Tobago result, the numerical values of the C/N ratios for the Trinidad and the Grenada soils are not identical with those for the Tobago soils, but they are of the same order of magnitude, and their differences are approximately the same.

A comparison of the climatic, cultural, and soil conditions within the three areas is instructive. The climatic differences are not very marked. Within each area, the annual rainfall (45 to 120 inches) is distributed between seven wet months (June to December) and five dry months. The cultural treatment is somewhat similar, except that leguminous shade trees (Immortel) are generally grown in the cacao fields of Trinidad and Tobago, but not in those of Grenada, whilst artificial manures are regularly employed in Grenada, but not in the other islands. The soil types are markedly different. The cacao soils in Trinidad are mainly derived from Tertiary sedimentary rocks and from their recent alluvial representatives, but some alluvial soils of the Northern Range of mountains are derived from Palaeozoic dynamo-metamorphosed sediments. The cacao soils of Tobago are about equally distributed between (*a*) metamorphic sedimentary rock types, similar to those of northern Trinidad; (*b*) partly metamorphosed, intrusive basic igneous rock (epidiorite) types; and (*c*) alluvial equivalents of both. The cacao soils of Grenada are derived from Pleistocene basic volcanic rocks (hornblende and augite andesites and olivine basalts; lavas, intrusions, and fragmental rocks) or their alluvial derivatives. Detailed studies of all these soil types are now being prosecuted at the College, and include a special investigation of the transformations of their organic matter contents. It is hoped thereby to discover the true significance of the C/N ratio of soil organic matter in its relation to nutrition of the cacao tree.

* Unpublished Thesis in part fulfilment of the requirements of the Associateship of the Imperial College of Tropical Agriculture, Trinidad, B. W. I., session, 1929-30.

REVIEW.

Modern Milling of Sugar-Cane.

By Francis Maxwell. Crown Quarto 424 pp. 250 illustrations. Price 50*s*. nett. *Norman Rodger*, London.

This book is a carefully detailed work on the construction and operation of milling plants. In a sense, it is unique in its field in that as it deals with nothing but the mill house, it is of more than usual interest to sugar engineers and technologists.

The general scheme of the book is to devote a chapter to each of the several units which go to make up a milling train. The individual topics are, therefore, fully discussed, and numerous figures and drawings are used for the purpose of illustration. In some cases, it seems that the number of these illustrations is excessive, but when it is remembered that the book deals with mills and mills only, this fault really becomes a virtue.

The author has drawn on his wide experience in the sugar field to discuss and present the data and his conclusions appear, in most cases, to be unbiassed. In the Preface he states that the subject of milling engineering has not received the attention that is due to its importance, and that this work is offered as an endeavour to mitigate this short coming. Dr. Maxwell is to be congratulated on a compilation which the sugar engineering world will greatly appreciate and of which its author may justly be proud.

J. G. D.

FIG. 4.—*Leaf inoculated with "Septoria lycopersici."*

FIG. 5.—*Leaf inoculated with "Phoma destructiva."*

PACKING TOMATOES IN BERMUDA.

FIG. 1.—*Exterior view of Packing Shed.*

FIG. 2.—*Interior view of Packing Shed. For description see text.*

PACKING TOMATOES IN BERMUDA.

BY

E. A. McCALLAN.

Director of Agriculture, Bermuda.

LAST season nearly 80 per cent. of the tomatoes exported from Bermuda were packed by the Department of Agriculture in the Government Packing House situated on the Agricultural Station grounds.

The dimensions of this packing house are as follows: Length of packing floor, 100 feet; width, 20 feet; height to wall-plate, 8 feet; to ridge, 13 feet. In the rear of the packing floor a loft 20 feet by 20 feet and six feet to wall-plate provides storage space for empty crates. The packed crates are stored below in a room of the same floor dimensions as the loft, and six feet six inches high. The frame of the building is of pitch-pine, and is covered with corrugated galvanised iron sheets on sides and roof; the floor, of concrete, is overlaid by a wooden floor on which the packers stand.

A Cutler 24-bin tomato grader stands in the centre of the building with feeding table 27 feet from the end of the building at which the tomatoes are delivered for packing; this gives about 500 square feet of floor space on which to stack the tomato farm boxes. Along either side of the building and behind the packers are two lines of gravity conveyors; the upper lines extending to the loft and delivering the empty crates within reach of the packers; the two lower lines conveying the packed crates to the nailers' table in rear of the machine. From the table, the crates are delivered to the storage room by a shute. Lining papers are hung from rods above the bins and in front of the packers. Under the conveyors there are boxes containing wrappers from which the wrapper trays are refilled on the left of the packers' stands. On each tray is a needle holder which prevents the wrappers from being blown out of the trays and enables a packer to draw off one sheet at a time. Each packer is provided with a rubber finger stall which is worn on the second finger of the left hand. The packers' stands are hung on the front of the bins and hold the crates while they are being packed.

The grader has given full satisfaction during the short time it has been in use. The fruit which is not damaged in the least during its passage through the machine is graded by weight and not by size. Six separations are possible, but only four are made, namely, 50's, 72's, 98's and 128's. A fifth size called gems, goes over the tail of the machine, and is packed unwrapped. The balance weights are very quickly adjusted, and frequent adjustments are made because of slight variation in the shape of the tomatoes.

The fruit which passes direct from the sorting table to the sizing belts is delivered, according to size, in the first six bins on either side of the machine. Fruit which is placed on the two belts above the sorting table is carried to the twelve bins (six a side) at the rear end of the machine. This makes possible three separations for degrees of maturity and four separations for size in each of the three degrees of maturity.

The workmen are under the direction of a Produce Inspector of the Department, who is foreman also. In addition to supervising the grading and packing he receives the tomatoes from the growers' carts and delivers the packed fruit to the carriers' carts for cartage to the dock. One man feeds the grader, removes the culls and keeps the floor clean. Sorters number two to four. Two men nail and stencil the packed crates. Another man keeps the bins from piling up at the back, fills the paper boxes and trays, and packs when not otherwise engaged. Another helps to stack the packed crates, loads the carts, and keeps the upper conveyors filled with empty crates.

The packers are white women, and are supervised by a young Scotch woman. This type of help is recruited from the families living near the Station, and the majority are housewives who are pleased to earn pin-money on two or three days a week. From 16 to 24 packers are required.

No definite information can be given regarding the maximum capacity of the machine and workers, for neither have yet found themselves. About 180 crates per hour have been graded, but this is less than half the advertised capacity of the machine. No accurate information can be given regarding the cost of packing under the conditions described. As already intimated, the help employed last season was untrained, and acquired speed and accuracy only as the season advanced. With labour as high as it is in Bermuda, the purchase of a mechanical grader was necessary. Not only does this machine size the fruit more accurately than if it were done by hand, but it speeds up all the operations connected with grading and packing. The machine cost £248 and the gravity conveyers £231.

Bermuda tomatoes are of the Bonny Best variety. They are packed in lugs or crates lined with blue paper which hold 20 lb. nett each. Each fruit, except gems, is wrapped separately in paper on which the Colonial Mark is printed in two colours. The wraps are of three sizes, seven, eight and nine inches square respectively. Each box contains the packer's numbered slip. The Colonial Mark is printed on attractive labels pasted on the crates, and on each crate is stamped, the Inspector's number, the weight and pack.

The prices obtained for Bermuda Government-packed tomatoes last season justified the expenditure.

ACKNOWLEDGMENT.

We have to acknowledge with thanks the following Journals which have been presented to the Library by the Academy of Natural Sciences of Philadelphia.

Fifty-nine volumes of the Proceedings of the Academy of Natural Sciences of Philadelphia covering the years 1860-1909.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

The Chemist and the Plant Breeder.

The following abstract, taken from the Editorial of the issue for 20th November, 1931, of *Chemistry and Industry*, may interest tropical planters.

Success in the elimination of an adverse quality or factor from a plant, has been attained in Germany in several instances, particularly that of the *lupin*. This plant grows easily on light soils and produces a considerable amount of protein, but the presence of bitter poisonous alkaloids in the green stalks and leaves, as well as in the seeds, has hitherto restricted its use to green manuring, and prevented its use as a fodder plant. Occasional sweet plants, free from alkaloid, have been discovered as the result of testing individually more than a million-and-a-half lupin plants, use being made of a very simple chemical precipitation reaction which has enabled many thousand single plants to be examined in a day. Fortunately, these sweet plants are found to breed true, and now, in consequence, enough seed has been collected to ensure that in about two years' time large field crops of edible sweet lupin can be grown on the light sandy soils, and it is hoped that these will prove most valuable fodder crops. Working on similar lines, it has been possible to obtain a variety of *Melilotus albus* free from the objectionable coumarin; this will be another useful forage plant.

Plant breeders have even progressed so far that varieties of *tobacco* have been bred which are free from nicotine, but otherwise highly aromatic and satisfactory to smoke. Progress in work of this kind is immensely facilitated by the availability of quick chemical methods of testing for very small quantities; great strides are being made in our technique of handling very small quantities, and it is undoubtedly one which the intending biochemist should master; the "emulsin" test for plant glycosides, and the picrate paper test for hydrogen cyanide are examples which come to mind. There are many heritable factors in plants which have a chemical basis of which we shall some day understand the nature.

A problem of the day is to breed a *tomato* with a skin which is firm and resistant enough to endure cold storage from the end of September onward, so as to be sold in perfect condition in mid-winter; the wild species have such a skin, but they only have small berries. It is within the memory of many that the cultivation in quite recent years of the tomato has resulted in the elimination of the strong flavour and smell of its earlier progenitor. We are warned that a new terror is in store for plants, for it has been found that maltreatment with chemicals or with X-rays will cause a large increase in the number of mutants or plants which in some way or other depart from the normal in every sowing.—(*J. Soc. Chem. Indus.*, Vol. 50, No. 47, 20th Nov., 1931, p. 946.)

A New Synthetic Rubber.

The du Pont Chemical Company of New Jersey, U.S.A. have recently announced that they are erecting plant for the manufacture of a new synthetic rubber to which the trade name "Duprene" has been given. The product is obtained by polymerisation of chloroprene (chlorobutadiene). The initial raw material is acetylene gas, which is first polymerised to mono-vinylacetylene, and then chlorinated to chloroprene.

Since the time when knowledge of the exact composition and relationships of the hydrocarbon caoutchouc led to the synthesis of this substance from isoprene, chemists have repeatedly failed to produce a material equal to natural rubber in physical properties, although their product is identical with it in chemical composition. The originators of "Duprene," however, claim that their new synthetic substance is actually superior to natural rubber in certain respects, and that it forms quite a satisfactory substitute for it for many of its present uses.

Chloroprene differs from isoprene only in the substitution of a chlorine atom for a methyl group. It polymerises spontaneously and very rapidly into a fully vulcanised rubber, which it is not necessary to treat with sulphur in order to effect vulcanisation. The polymerisation, moreover, may be stopped at an intermediate stage, yielding a rubber of marked plasticity, and similar in many ways to ordinary unvulcanised or raw rubber. This intermediate product may be compounded with fillers and other ingredients, and the polymerisation may then be completed merely by heating the mixture to 130°C.

"Duprene" is stated to be denser, more resistant to water, less swelled by solvents, less porous to gases, more tough, and more resilient than natural rubber. Polymerisation may readily be induced in chloroprene emulsified in water, the product resembling vulcanised latex, whose component particles, however, are much smaller than those of caoutchouc present in natural latex. The material obtained by evaporating the emulsion is very plastic. The emulsion itself may be used for impregnating paper and fabrics whose fibres it easily penetrates because of the small size of the particles.

Although the cost of production of "Duprene" will be many times greater than the present market price of natural rubber, it is believed that many commercial uses will be found for it because of its unique properties.—(News Edition, *Indus. Engin. Chem.*, 10th Nov., 1931, Vol. IX, No. 21, p. 321.)

VERMOREL SPRAYERS.

We learn from Messrs. Cooper, Pegler & Co., Ltd. that their Vermorel Sprayers were favourably commented upon in a report recently issued by an Agricultural Machinery Testing Committee appointed by the Ministry of Agriculture and Fisheries.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Notes on the Deterioration of Raw Sugar in Storage. *N. E. Lamont.*

That the question of the careful study of the best conditions for the storage of raw sugars in the tropics, especially during the wet season, is one of vital importance, especially at the present time when large stocks are often of necessity held over to await more favourable market conditions, was recently brought to the notice of the writer. A large lot of 98° raw sugar, initially carrying a moisture content of 0.5 per cent., was placed in the factory store which has been found to serve well for the purpose during short periods. This sugar, however, was retained in the store for a period of three months during the wet season without provision being made for heat and moisture regulation and the results proved disastrous.

During the period named the rainfall had averaged 31.5 ins.; and the pol. had dropped to an average figure of 92°, a figure varying considerably according to the position of the bags which had been piled 20 high. In fact, the outer bags in the piles had run to molasses, so considerable was the deterioration. Then the sugar was sent over to the adjacent "Sumacarb" refinery, where it went through the usual affining operation prior to re-melting. But even when taking every care to use the minimum of water, the loss on affining amounted to over 20 per cent.; further, the recovery of the sugar in the affination syrup was an impossibility, its sucrose being immediately inverted, though steps to neutralize it were promptly taken. No more than 82 per cent. of the sugar originally present in the once 98° sugar could be recovered in all strikes.

No attempt was made to isolate and classify the micro-organisms concerned in this deterioration; but their disastrous effect was brought further home by the following simple experiment. A quantity of plantation white sugar was inoculated with some of the affination syrup, and sewn up in four of the cotton bags in which it is usually stored. Originally this sugar was found to test: pol. 98.8, glucose, 0.20 per cent. and moisture 0.30; while after the inoculation the figures were 97.1, 0.69 and 1.19 per cent. Then during a month the following observations were made:

Day.	Rainfall. ins.	Pol.	Glucose per cent.	Total Sugars per cent.	Gain or loss in Weight.
7th	9.87	92.80	2.72	95.52	+ 2.15
14th	4.31	86.75	5.68	92.43	+ 3.99
21st	0.61	79.30	7.35	86.65	— 3.77
28th	2.42	78.70	8.60	87.30	— 5.00

In the table above it will be noticed that the increase in weight continued until the end of the 14th day, after which the maximum saturation had been reached, the molasses then commencing to run, so as to occasion a steady loss of weight, together with yet further deterioration of sucrose. While perhaps this may be an exaggerated case, though an actual one, it serves to bring vividly to one's notice the enormous losses which may be occasioned through want of sufficient care regarding storage conditions. It emphasizes the necessity of taking steps to construct the sugar store according to modern scientific ideas, especially in regard to the careful control of the humidity.—(*Int. Sugar Jr.*, Vol. XXXIV, No. 397.)

* * *

Preservation of Sugar-Cane Seed. *G. B. Sartois.*

The seed of sugar-cane shows a considerable range of viability, often from only a few days up to three months. This uncertain viability is considered to necessitate haste in planting and is a serious bar to shipments of seed from one country to another in cases where much time will be consumed in transit. From numerous experiments it has been found that by packing the seeds in mason jars partly filled with calcium chloride and storing them at room temperature, they could be maintained viable for eight months.—(*Facts about Sugar*, Vol. XXVII, No. 1.)

* * *

Froth Fermentation in Table Syrup Manufacture. *S. J. Saint.*

A number of advisory visits were made by the Chemist of the Department to syrup factories where difficulty was being experienced with a fermentation after the molasses had been discharged into the coolers. This trouble was new to many experienced syrup manufacturers, and its frequent occurrence during this crop season would appear due to some abnormal properties of the juice owing to the dry growing season of 1930. It was obviously allied to the froth fermentation which sometimes takes place in low purity massecuites which have been boiled at too high a temperature.

The syrup would be perfectly normal on leaving the Aspinall pan, and if it cooled quickly it retained its colour and flavour. But if this same molasses were discharged into a tank, where it retained average temperature of say 180°F to 190°F for as much as 24 hours, it would turn red and a dirty white froth would appear on its surface; eventually caramelization would take place with the result that the syrup would darken and acquire a burnt flavour. Froth fermentation of massecuites is considered to be due to reactions between amino-acids and invert sugar resulting in the evolution of carbon dioxide.* Such reactions, however, only take place at a high temperature.

It was found that the fermentation of fancy molasses could be prevented by cooling the syrup as it left the Aspinall pan rapidly to a temperature of about 160°F (71°C). It could then be safely run into tanks to cool without the slightest risk of fermentation. This initial cooling can be carried out by allowing the syrup during its passage from pans to tanks to run along a shallow trough or fall over a cooling tower, or pass through a juice-heater through which cooling water was being circulated.—(*Int. Sugar Jr.*, Vol. XXXIV, No. 397.)

* *International Sugar Journal*, Vol. XVI, No. 185, p. 230.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.	*Preferential.*
	s. d.	*s. d.*
7th January ..	7 0	10 $9\frac{3}{4}$
14th January ..	7 $0\frac{3}{4}$	10 9
21st January ..	6 $11\frac{1}{4}$	10 $7\frac{1}{2}$
28th January ..	6 $10\frac{1}{2}$	10 $6\frac{3}{4}$
4th February ..	6 $9\frac{1}{2}$	10 6
11th February ..	6 $5\frac{1}{4}$	10 $1\frac{1}{2}$
11th Feb. (1931)..	6 0	9 $4\frac{1}{2}$

The market which was a little firmer at the beginning of the year has more recently been somewhat subdued with prices tending to recede. The attention of the Sugar World has been mainly focussed to events in connection with the resumption of the International Sugar Conferences the date of which, although provisionally fixed for 5th January, was postponed. Discussions have been going on within the Java Industry with a view to arriving at the best method of meeting the existing statistical position but no decision has yet been reached. In the meantime 47 Cuba centrals started grinding on 15th January as against 83 mills at the same time last year.

* * *

COCOA.—The cocoa market continues extremely dull with no immediate prospect of improvement. Despite the fact that the main Accra crop is at an end, prices are easier. Latest available quotations in London for Accra are 24*s.* to 25*s.* and Trinidad $7 a fanega is freely offered.—(*By courtesy of the Cocoa Planters' Association, Trinidad.*)

* * *

COFFEE AND TEA.—The tone of the market has improved quite noticeably especially in regard to East African varieties which seem to be replacing common Brazilian. Latest quotations per cwt. include Kenya 95*s.* to 152*s.*, Costa Rica 88*s.* to 128*s.* 6*d.*, good ordinary Jamaica 65*s.*

Tea averages (per lb.) are lower at Ceylon 14.75*d.*; Indian 10.73*d.*; and Java 8.33*d.* The market is quiet and suffering from the continued low standards of consignments from what used to be quite fair quality districts.—(*Times, Trade and Eng. Supp.*, 23rd January.)

* * *

COPRA.—West Indian f.m.s. continues firm and unchanged at £15 17*s.* 6*d.* net c.i.f., London.—(*West India Committee Circular*, 21st January.)

RUBBER.—Quotations for Plantation Sheet have ranged as follows :

	d.
6th January	$3\frac{1}{8}$
13th January	$3\frac{5}{8}$
20th January	3
27th January	3
3rd February	$2\frac{13}{16}$
10th February	$2\frac{3}{4}$
11th Feb. (1931)	4

The market has remained dull and inactive with only small fluctuations in price. Production is stated to be going on, on very much the same scale as in 1929, although the 1391 consumption will show a reduction of nearly 20 per cent. on 1929. No further news is available regarding the prospects of Government restriction.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
31st December ..	5.39	7.05
8th January ..	5.33	7.05
15th January ..	5.41	7.25
22nd January ..	5.52	—
29th January ..	5.49	—
5th February ..	5.52	—
12th February ..	5.59	—
10th February (1931)	5.77	—

Prices of American have shown a very steady tone with a tendency to advance. Ordinary West Indian quotations are higher, good fine 5.85*d.*; good 6.35*d.*; fine 7.10*d.*; extra fine 7.60*d.*

* * *

BANANAS.—Jamaicas continue in fair demand at the unchanged price of £20 5*s.* per ton delivered London, or £20 delivered nearest railway station. Brazilians are also unchanged at £18 per ton delivered nearest railway station, and in fair demand.

The total imports into the United Kingdom last year were 16,161,732 bunches as compared with 14,989,564 bunches, and 14,936,719 bunches in 1930 and 1929 respectively.—(*West India Committee Circular*, 21st January.)

* * *

LIME PRODUCTS.—*Lime Oil.*—Handpressed continues slow; the last nominal value was 60*s.* There is no demand for Distilled and prices remain nominal. *Lime Juice.*—No business has been reported during the fortnight and the value of £5 is unchanged. Small sales of Raw have been made at 2*s.* 6*d.* for good Jamaica.—(*West India Committee Circular*, 21st January.)